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Golden Anniversary of Athletic Training 50 NATA

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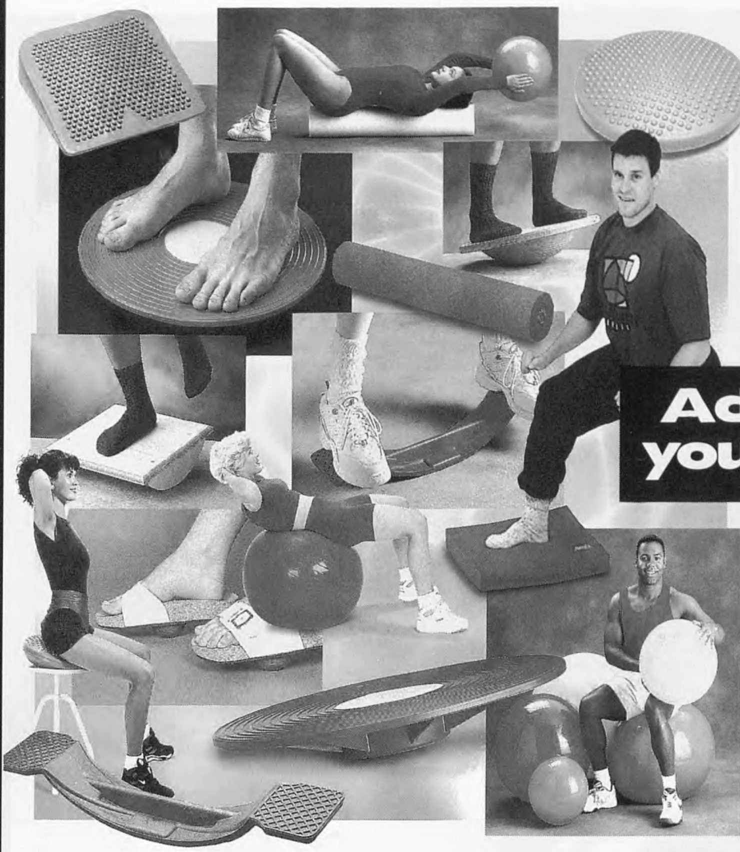

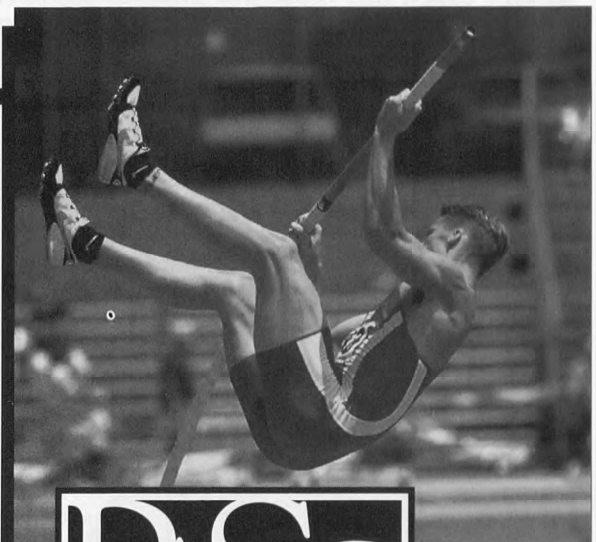

2000 Pre-Olympic Congress

7-13th September 2000

BRISBANE, AUSTRALIA

SPONSORSHIP OPPORTUNITIES

The Congress has many great opportunities for companies and discipline groups to promote their products and services, including:

- Signage at the venue
- Satchel fillers
- Identification in promotional material
- website identification and links
- Special event sponsorship
- Trade display space

TRADE DISPLAY

A trade exhibition will run alongside the Congress, with exhibits ranging from books, pharmaceuticals, computers, apparel, sporting equipment and the latest technology. Delegates will have the opportunity to view and discuss this showcase of the latest developments in a relaxed atmosphere.

Important Dates

Abstract submission
11th Feb 2000

Notification of acceptance
May 2000

Early registration
June 2000

Congress Themes

Sports Medicine

- Drugs in sport
- Advances in management of bone and soft tissue injuries
- Medical issues for the elite athlete
- Sports medicine in the twenty-first century

Physical Therapies

- Current trends in the diagnosis, prevention, management and rehabilitation of sporting injuries
- The Olympics of the Physical Therapies
- Therapeutic exercise approaches to the prevention and rehabilitation of the injured athlete
- Podiatric approaches to the prevention and treatment of sporting injuries

Biophysical

- Anthropometry and Body Composition
- Elite Athletes
- Population Trends in Physical Activity
- Biochemistry, Neuromuscular and Cardiovascular Physiology
- Exercise and Special Populations
- Sport and Society

Sociocultural

- The body and sport: gender, race, disability and technology
- Ethics, law and politics in sport
- Sport and Globalisation
- The sports industry: economics, marketing and management
- Technology, the media and sport

Nutrition and Health Promotion

- Energy Balance
- Athletes as role models for health
- Lastest advances in Sports Nutrition
- Nutrient deficiencies - who, how, when and best prevention methods
- Detection of eating disorders
- Health Promotion and Nutrition in the 21st Century

Pedagogy

- Youth Wellness: Challenges and Strategies for the future
- Learning for all: Contexts and Responsibilities
- Physical Activity: Moving On
- Sport: Don't Leave it to Chance

Psychology

- Exercise and health in sport psychology
- Social, cognitive and behavioural aspects in sport psychology
- Applied issues in training and treating athletes in sport psychology

SECOND ANNOUNCEMENT

The second announcement will be available soon. To ensure you receive your copy without delay please Email your details to Amanda at the contact details below.

Pre and Post Touring Ideas

The Congress has a number of pre and post touring options for delegates and their partners. Make sure you are on the mailing list for the second announcement to find out the details about these great touring opportunities. Listed below are a few of the many options available.

X Experience a unique undersea world when you dive or snorkel the Barrier reef.

A Laze on a secluded beach and forget your cares

✯ visit one of Australia's many zoos and come face to face with our native animals

Two days post conference, you will have the opportunity to take a one hour flight to Sydney and share the triumphs and tears with the athletes at the 2000 Olympic Games

Programme

Below is a basic outline of the Congress Program

	Day	Afternoon / Evening
Thursday 7th	Workshops	
Friday 8th	Workshops	Opening Ceremony
Saturday 9th	Conference	Social event
Sunday 10th	Conference	Social Event
Monday 11th	Conference	Dinner Dance
Tuesday 12th	Conference	Great Debate and closing

Accommodation

Ozaccom has secured a number of rooms at various hotels around the city. Rooms range in price from AUD50 per night for the budget conscious to AUD280 for those wishing to be pampered. Please contact Ozaccom, for all enquires ozaccom@ozaccom.com.au

WE LOOK FORWARD TO WELCOMING YOU TO BRISBANE

Olympic Football - Brisbane

The Congress is excited to announce that we have secured tickets to the Opening night of the Olympic Football match to be held in Brisbane on Wednesday 13th September. So If you aren't planning to head to Sydney after the Congress, this is your chance to catch some of the Olympic Fervour

For Further information on the Congress, please contact

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Editorial

JAT: Past, Present, and Future

David H. Perrin, PhD, ATC
Editor-in-Chief

This—our last issue of the 20th century—is also the final of 4 commemorative issues marking the 50th-year anniversary of the National Athletic Trainers' Association. In this issue, you will find a classic editorial written by Art Dickinson in 1956 and a 50th-year commemorative article on the history of our professional journal written by 2 noted contributors to its evolution, Ken Knight and Clint Thompson. Art Dickinson's editorial is remarkable because its general themes are as applicable today as they were more than 40 years ago. The Knight and Thompson commemorative article masterfully follows the evolution of our journal from its humble beginnings to the respected place it now holds among sports medicine periodicals. As we head into the 21st century, I am pleased to provide the following information attesting to the health and strong standing of the *Journal of Athletic Training*.

The *Journal* now has a circulation of nearly 27000 subscribers in the United States and 38 foreign countries. Subscribers include certified athletic trainers, physicians, physician assistants, certified strength and conditioning specialists, chiropractors, emergency medical technicians, occupational therapists, physical therapists, and other members of the sports medicine, exercise science, and allied health care communities. The Editorial Board of *JAT* reflects many of these key members of the sports medicine team and includes representatives from Canada, the United Kingdom, Austria, Israel, and Japan.

From August 1996 through September 1999, 361 manuscripts were submitted to *JAT*, for an average of 120 papers per year. This required 2196 manuscript reviews by 355 Guest Reviewers, 53 Editorial Board members, 8 Associate Editors, and 1 Editor-in-Chief. Of these submissions, 41% were ultimately accepted for publication, with an average time to acceptance of 236 days (range, 61 to 499 days). These submissions, combined with the exemplary work of the manuscript reviewers and *Journal* office staff, have led to a healthy backlog of accepted articles equivalent to approximately 2 issues of *JAT*.

To address the growing interest in *JAT* and to provide readers with additional and timely information related to education and research in the domains of sports medicine research and clinical practice, we have made several changes to the content of the *Journal* and have requested others of our Board of Directors. We have deleted the Current Literature and Abstracts sections of the *Journal* so that we can immediately print more original articles of interest to our readers. Our rationale was that major improvements in library and World Wide Web technology have made computer literature searches accessible to virtually everyone. Special thanks go to Clint Thompson for preparing the Current Literature and Abstracts sections of *JAT* for many years.

Future goals include an increase in the number of pages devoted to the publication of articles and a clinical supplement to accompany the regular issue of *JAT* every 4 to 6 issues. This initiative is due in part to the exceptional manner in which our special issue, "Anterior Cruciate Ligament Injuries in the Female Athlete," was received by the sports medicine community. Not only will this increase the number of pages available for current research, but, at the same time, it will provide additional information to the many clinical practitioners of athletic training who read *JAT*. We are currently finalizing preparations for our next special issue, which will deal with the shoulder.

The volume of research conducted by certified athletic trainers has grown tremendously in the last 10 years. We have witnessed the development of doctoral programs designed specifically for athletic trainers and the establishment of athletic training research laboratories for clinical investigation of the prevention, evaluation, management, and rehabilitation of injuries. To mark this growth in research conducted and published by athletic trainers, we will occasionally invite a commentary and author's response on an article published in *JAT*. You will find the first of these commentaries in this issue, and I hope that these commentaries will help to advance the sophistication of research conducted and published by athletic trainers.

My predecessors and the many others mentioned in the Knight and Thompson commemorative article deserve enormous credit and thanks for the evolution of the *Journal of Athletic Training*. I continue to be thankful for the good work and support of the many people currently involved with *JAT*: the editorial office staff and Associate Editors, the Editorial Board and Guest Reviewers, President Kent Falb, our Board of Directors, the NATA office staff, and, of course, the authors who select *JAT* as the outlet for their work. The dedication of these people and the changes I have described and proposed in this editorial will continue to advance the *Journal*'s standing among sports medicine periodicals into the next century.

Journal of Athletic Training 1999;34(4):328–333

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The Relationship of Body Weight and Clinical Foot and Ankle Measurements to the Heel Forces of Forward and Backward Walking

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Objective: To compare and contrast the relationships of selected static clinical measurements with the heel forces of forward and backward walking among healthy high school athletes.

Design and Setting: Single-group, cross-order-controlled, repeated-measures design. All data were collected in a high school athletic training room.

Subjects: Seventeen healthy high school student-athlete volunteers.

Measurements: We performed static clinical measurements of the foot, ankle, and knee using handheld goniometers. We used a metric ruler to assess navicular drop and a beam balance platform scale to measure body weight. Mean peak heel forces were measured using F-scan insole force sensors. Data were sampled for 3 5-second trials (50-Hz sampling rate). Mean peak heel forces were determined from 3 to 5 consecutive right foot contacts during forward and backward walking at approximately 4.02 to 4.83 km/h (2.5 to 3.0 mph). Subjects wore their own athletic shoes and alternated their initial walking direction.

Results: Forward stepwise multiple regression analyses revealed that body weight, navicular drop, and standing foot angle predicted mean peak heel forces during forward and backward walking.

Conclusions: Heel forces during forward and backward walking increase as body weight and navicular drop magnitude increase, and they decrease as standing foot angle increases. Subtle differences in foot, ankle, and knee joint postures and kinematics can affect heel forces even among normal subjects. Injury and protective bracing or taping may further affect these heel forces.

Key Words: biomechanics, gait, goniometry, posture

Lower extremity injuries are often caused by repeated, excessive, or inappropriately timed heel forces, or a combination of these, during locomotion.[1–9] Heel pain is a common malady affecting athletes with various foot and lower extremity alignments and may be related to more proximal kinetic chain dysfunction.[10] Poorly controlled rearfoot motion, decreased gastrocnemius-soleus extensibility, and hip and knee malalignments have been associated with numerous lower extremity injuries, including heel injuries.[1–10]

McPoil and Cornwall[11] examined the relationship between 17 static lower extremity measurements and rearfoot motion during forward walking among 27 healthy young adults and reported that only navicular height was predictive of maximum rearfoot pronation. The researchers concluded that, although these measurements provided important data regarding the range of motion and static alignment of the lower extremity and foot, they were limited in their overall usefulness in predicting walking stance-phase kinematics. Using multiple regression analysis, Cavanagh et al[12] examined the relationship between 27 radiographic static structural foot measurements of 50 healthy adults and dynamic foot function, reporting that soft tissue thickness and "arch-related" measurements were the strongest predictors of heel and first metatarsal head pressures (explaining approximately 35% of the dynamic plantar pressure variance). Birke et al[13] compared diabetic patients with a history of plantar surface ulceration at the first metatarsal head and matched nondiabetic controls, reporting a moderate inverse relationship between first metatarsal dorsiflexion and peak pressure at the first metatarsal head ($R^2 = -0.46$, $P < .0001$).

Backward walking and other "retro" movements are becoming increasingly popular rehabilitation methods to enhance ankle and knee joint range of motion and selectively activate muscle groups such as the ankle dorsiflexors and knee extensors.[14–16] During forward walking, weightbearing is usually initiated at the posterolateral heel, proceeds distally along the lateral foot, and terminates in the vicinity of the first metatar-

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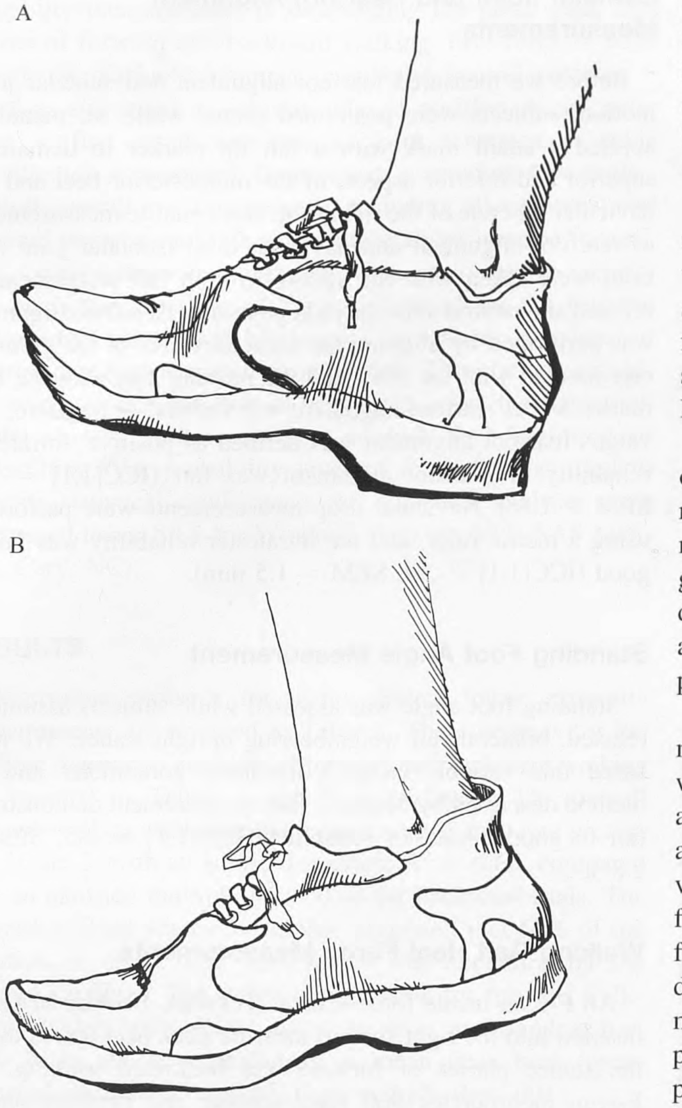

A, Forward-walking stance-phase initiation. B, Backward-walking stance-phase initiation.

sophalangeal joint.[17] During backward walking, this progression is reversed (Figure).

Based on these biomechanical considerations, altered ankle dorsiflexion, first metatarsophalangeal joint extension, or both, might affect heel forces in either walking direction. Ankle dorsiflexion increases may increase heel forces as the foot is biased toward the heel during early forward-walking stance phase or may increase heel forces during backward walking by prolonging the stance phase. First metatarsophalangeal joint extension decreases may also affect these forces as the transition from initial weightbearing to propulsion is compromised in either walking direction.

Navicular drop refers to the amount the tubercle of the tarsal navicular drops when the foot moves from neutral or balanced subtalar joint alignment to a "relaxed" subtalar joint alignment during full weightbearing stance. Neutral subtalar joint positioning was defined as the position in which the talar head was equally prominent to mediolateral palpation as the subject actively pronated and supinated the right foot during bilateral full weightbearing stance.[1] Previous studies have reported that increased navicular drop may predispose athletes to lower extremity injury.[1,11,18,19] We hypothesized that navicular drop increases would be related to increased heel forces in either walking direction.

On the basis of its bony attachments, reduced rectus femoris musculotendinous extensibility would tend to promote walking with greater hip flexion and decreased knee flexion, possibly shortening walking stride length and thereby altering heel forces. We hypothesized that increased rectus femoris extensibility would increase mean peak heel forces via greater stride lengths and more efficient walking gait.

Standing foot angle, or the Fick angle, represents the amount of toeing in or out during normal relaxed stance.[1] Reported ranges for this measurement vary with increasing age, and many studies have recorded this measurement during walking gait.[20–22] We hypothesized that increased toeing out would decrease peak heel force magnitude because more weight is accepted on the lateral aspect of the foot during walking stance phase.

Standing rearfoot angle refers to the frontal plane alignment of the posterior aspect of the heel during relaxed, full weightbearing stance.[1,23] A more valgus heel alignment is associated with greater impact force-attenuating capability and less effective propulsive-force capability.[10] A more varus heel alignment is associated with greater propulsive force-producing capability and less effective heel-contact force attenuation. Excessive or restricted motion in either direction during walking stance phase is not desired and may affect peak heel forces. We hypothesized that, as positive rearfoot alignment increased (greater valgus), mean peak heel forces would decrease.

The ability to predict peak heel forces from static clinical lower extremity measurements would be useful in screening for at-risk athletes and monitoring the effectiveness of treatment strategies designed to prevent both heel and foot injury and related proximal lower extremity microtraumatic (overuse) injury.[5–9,11,12] Although previous studies have compared static lower extremity clinical measurements with forward walking kinetics, comparisons have not been made with backward walking.[5–9] Also, previous investigations have not assessed variables such as rectus femoris and gastrocnemius-soleus musculotendinous extensibility or standing foot angle.

Arguably, many static lower extremity postures or foot, ankle, and knee soft tissue restrictions could influence heel forces during walking. Since multiple factors may influence these forces, multiple regression analysis may be the preferred method of estimating the relative effects of selected test variables. We compared and contrasted the relationships of selected static clinical lower extremity measurements with the mean peak heel forces of forward and backward walking among healthy high school athletes via multiple regression analysis.

METHODS

Subjects

Seventeen (7 female, 10 male) healthy high school student-athlete volunteers (age = 15.5 ± 1 years, weight = 65.77 ± 3.18 kg [145 ± 7 lb], and height = 170.18 ± 12.70 cm [67 ± 5 in]) participated in this study. Body weight was measured with a beam balance platform scale (Micro BioMedics Inc, Pelham Manor, NY). Subjects practiced forward and backward walking at preferred test trial velocity range (4.02 to 4.83 km/h [2.5 to 3.0 mph]) before data collection (approximated by the investigator with a handheld stopwatch).

Knee, Ankle, and First Metatarsophalangeal Joint Flexion-Extension Measurements

These measurements were collected by the principal investigator using a handheld goniometer and previously described methods.[24–26] Subjects were positioned supine and were barefoot, and the right lower extremity was used for all measurements. Pilot intratester test-retest reliability assessments (5 subjects) were performed for each measurement before data collection.

The modified Thomas test was used for hip flexor (specifically the rectus femoris muscle) extensibility assessment.[26] During this test, subjects were positioned with the right knee flexed over the edge of a treatment table. While in this position, they used their upper extremities to position and maintain the left knee against the chest. After this position was attained, they actively flexed the right knee as far as possible while maintaining right thigh-treatment table contact. When maximal active right knee flexion was reached, we took a goniometric measurement. This measurement demonstrated high intratester reliability (intraclass correlation coefficient [ICC][1,1] = .89, SEM = 2.5°).

We measured active ankle dorsiflexion with the right knee extended.[25] While in this position, subjects actively dorsiflexed the right ankle as far as possible. When maximum active ankle dorsiflexion was attained, a goniometric measurement was taken. This measurement demonstrated fair to good intratester reliability (ICC[1,1] = .81, SEM = 1.1°).

Active first metatarsophalangeal joint extension was also measured with the right knee extended.[24,25] While in this position, subjects actively dorsiflexed the right ankle to a neutral 0° dorsiflexion-plantar flexion position (as verified with a goniometer). Upon attaining this position, subjects actively extended the first metatarsophalangeal joint. When maximal active first metatarsophalangeal joint extension was attained, the primary investigator performed a goniometric measurement while stabilizing the head of the first metatarsal. This measurement demonstrated fair to good intratester reliability (ICC[1,1] = .83, SEM = 2.5°).

Subtalar Joint and Rearfoot Alignment Measurements

Before we measured rearfoot alignment and subtalar joint motion, subjects were positioned prone, while we manually applied a small mark with a felt tip marker to demarcate superior and inferior aspects of the midposterior heel and the navicular tubercle of the right foot. Goniometric measurements of rearfoot alignment and navicular drop (subtalar joint motion) were taken with the athlete in both full weightbearing relaxed and neutral subtalar joint positions. Rearfoot alignment was performed by aligning the stationary arm of the goniometer parallel with the floor and the moving arm with the heel marks. Varus rearfoot alignment was defined as negative, and valgus rearfoot alignment was defined as positive. Intratester reliability of rearfoot alignment was fair (ICC[1,1] = .76, SEM = 1.3°). Navicular drop measurements were performed using a metric ruler, and the intratester reliability was fair to good (ICC[1,1] = .84, SEM = 1.5 mm).

Standing Foot Angle Measurement

Standing foot angle was assessed while subjects assumed a relaxed, bilateral full weightbearing upright stance. We measured this variable using a handheld goniometer and the method described by Magee.[1] This measurement demonstrated fair to good intratester reliability (ICC[1,1] = .85, SEM = 2.8°).

Walking Gait Heel Force Measurements

An F-scan insole force sensor (Tekscan, Boston, MA) was inserted into the right shoe to measure peak heel forces during the stance phases of forward and backward walking. The F-scan incorporates 960 force-sensing and pressure-sensing cells beneath the entire plantar surface of the foot. The ultrathin (0.02-cm [0.007-in]) insole containing the sensors was trimmed to the subject's shoe size before insertion. Before data collection, the F-scan was calibrated to subject body weight during unilateral stance according to the manufacturer's protocol.[27] During calibration, body weights were input into the computer, after subjects assumed a unilateral right lower extremity stance position. After calibration, subjects were instructed to walk at their practice trial pace, and 3 5-second trials were collected (50-Hz sampling rate). Mean peak heel forces were determined from 3 to 5 consecutive right-foot contacts while subjects walked forward and backward at approximately 4.02 to 4.83 km/h (2.5 to 3.0 mph). Subjects wore their own athletic shoes during testing and alternated their initial walking direction to control for crossover effects.

Statistical Analysis

Descriptive statistical analysis was performed for all test variables. The following regression model was constructed to assess the predictive value of these static clinical lower extremity measurements in determining the mean peak heel forces of forward and backward walking: heel force = body weight + rearfoot alignment in subtalar neutral position + rearfoot alignment in subtalar relaxed position + navicular drop + first metatarsophalangeal joint extension + ankle dorsiflexion + modified Thomas test + standing foot angle.

Both overall (or "constrained," including all variables) and forward stepwise multiple regression analyses were performed. The forward stepwise regressions were performed to identify the predictive equation of "best fit" based on the selected independent variables.[28] Mallow's C(p) statistic was used to discriminate between regression models. This statistic considers both variance and bias in helping to select the regression model (lowest value) that best controls for overfitting or underfitting.[28] A probability level of $P < .05$ was used to indicate statistical significance. All statistical analyses were performed using SAS for Windows (version 6.11; SAS Institute, Cary, NC).

RESULTS

Descriptive statistics for static clinical lower extremity measurements are reported in Table 1. The outcomes for the multiple regression analyses of forward and backward walking are reported in Tables 2 and 3, respectively. The overall forward-walking trial multiple regression was the more predictive of the 2, with an adjusted multiple $R^2 = 0.60$, compared with an adjusted multiple $R^2 = 0.34$ for backward trials. The forward-walking regression model suggested that 60% of the variation in mean peak heel forces was explained by the selected variables. The stepwise regression for forward walking resulted in body weight, navicular drop, and standing foot angle being the best predictors of mean peak heel forces (adjusted multiple $R^2 = 0.63$, $C(p) = 2.85$, $P = .001$).

The overall regression model for backward walking suggested that the independent predictors explained only 34% of the mean peak heel forces, and the F value was not significant ($P = .18$). A possible reason for the better fit of the forward-walking model is the frequency with which subjects perform this task compared with backward walking, despite practicing before data collection.

When forward, stepwise regressions were performed, both the forward-walking (Table 4) and backward-walking (Table 5) regression models were significant. The stepwise regression for backward walking produced the same 3 significant variables (body weight, navicular drop, and standing foot angle) as for forward walking (adjusted multiple $R^2 = 0.47$, $C(p) = 1.35$, $P = .01$).

DISCUSSION

The strongest predictors for the mean peak heel forces of forward and backward walking were body weight, navicular drop, and standing foot angle. According to the forward stepwise multiple regressions for forward and backward walking, if body weight increased by 0.45 kg (1 lb), then mean peak heel forces would increase by a factor of 0.47 and 0.38, respectively. If navicular drop increased by 1 cm, then mean peak heel forces would increase by a factor of 23.7 and 18.1, respectively. If standing foot angle increased 1° in toeing-out stance, then mean peak heel forces would decrease by a factor of 1.65 and 1.38, respectively. When toeing out, less force appears to be placed at the heel and more force is placed at the lateral aspect of the foot.

The relationship between body weight and heel forces, even when walking at self-selected speeds, has tremendous relevance to the athletic arena. Since ground reaction forces may increase by a factor of 5 during running and jumping activities, heel forces should similarly increase. These increases may be particularly injurious to the heel if a rearfoot running style is employed.

Our study demonstrates the dramatic influence of subtalar joint displacement on heel impact forces during forward and backward walking. Athletic trainers can influence the magnitude and possibly the rate of this displacement via medial longitudinal arch taping, medial arch-stabilizing footwear, insoles or orthotics, and exercise programs designed to improve the neuromuscular responsiveness of ankle and subtalar joint muscles. Primary heel injury prevention can also be provided by specialized taping, which compresses fat pad tissue,[29] via padding with central relief, or heel cups.

Whereas athletic trainers can intervene at the medial longitudinal arch and the subtalar joint through both passive (taping, padding, footwear, or orthotics) and active (exercise) means, the influence of standing foot angle on heel forces may be less controllable. Based on our findings, we recommend that, in

Table 1. Descriptive Statistics for Static Clinical Measurement Variables

Variable	Mean	SD
Forward-walking peak heel force (kg)	56.36 (124.7 lb)	12.79 (28.2 lb)
Backward-walking peak heel force (kg)	54.48 (120.1 lb)	11.43 (25.2 lb)
Body weight (kg)	69.85 (154 lb)	15.20 (33.5 lb)
Standing rearfoot alignment in subtalar neutral position (°)	1.7	5
Standing rearfoot alignment in subtalar relaxed position (°)	4.8	5
Navicular drop (cm)	1.2	.50
1st metatarsophalangeal joint extension (°)	56.2	13
Ankle dorsiflexion (°)	5.4	3
Modified Thomas test (°)	102	10
Standing foot angle (°)	19.7	9

Table 2. Multiple Regression Analysis of Forward Walking: Overall Results (Dependent Variable = Mean Peak Heel Force)*

	Intercept	Body Weight	Standing Rearfoot Neutral (Valgus = +, Varus = −)	Standing Rearfoot Relaxed (Valgus = +, Varus = −)	Navicular Drop	1st Metatarsophalangeal Joint Extension	Ankle Dorsiflexion	Modified Thomas Test (Knee Flexion)	Standing Foot Angle (Toe Out = +, Toe In = −)
Regression coefficient	6.07	.481	4.07	−3.92	25.7	−.021	.075	.53	−1.48
SE	103	.20	2.64	2.87	14.2	.42	2.34	.63	.60
t score	.058	2.39	1.54	−1.36	1.80	−.05	.032	.85	−2.47

*Adjusted multiple R^2 = .60, F value = 3.92, $P > F$ = .035.

Table 3. Multiple Regression Analysis of Backward Walking: Overall Results (Dependent Variable = Mean Peak Heel Force)*

	Intercept	Body Weight	Standing Rearfoot Neutral (Valgus = +, Varus = −)	Standing Rearfoot Relaxed (Valgus = +, Varus = −)	Navicular Drop	1st Metarsophalangeal Joint Extension	Ankle Dorsiflexion	Modified Thomas Test (Knee Flexion)	Standing Foot Angle (Toe Out = +, Toe In = −)
Regression coefficient	−.89	.42	3.27	−2.93	22.1	.27	−.57	.47	−1.22
SE	118	.22	3.02	3.2	16.8	.49	2.67	.72	.68
t score	−.008	1.84	1.08	−.892	1.35	.563	−.213	.659	−1.77

*Adjusted multiple R^2 = .34, F value = 2.007, $P > F$ = .18.

Table 4. Multiple Regression Analysis of Forward Walking: Stepwise Results (Dependent Variable = Mean Peak Heel Force)*

	Intercept	Body Weight	Navicular Drop	Standing Foot Angle
Regression coefficient	55.8	.47	23.7	−1.65
SE	22	.13	9.39	.52

*Adjusted multiple R^2 = .63, C(p) = 2.85, F value = 10.1, $P > F$ = .001.

Table 5. Multiple Regression Analysis of Backward Walking: Stepwise Results (Dependent Variable = Mean Peak Heel Force)*

	Intercept	Body Weight	Navicular Drop	Standing Foot Angle
Regression coefficient	66.2	.38	18.08	−1.38
SE	23.8	.14	10.1	.56

*Adjusted multiple R^2 = .47, C(p) = 1.35, F value = 5.74, $P > F$ = .01.

addition to evaluating specific sport and position demands, athletic trainers consider body weight, navicular drop, and standing foot angle in the aggregate when deciding which athletes may be predisposed to sustaining a heel injury.

CONCLUSIONS

We found body weight, navicular drop, and standing foot-angle measurements to be the strongest predictors of mean peak heel forces during forward and backward walking. The lower adjusted multiple R^2 value and lack of statistical significance for the overall backward walking regression suggest that the subjects did not perform the task with the same consistency as forward walking or that variables other than those measured warrant consideration to accurately predict heel forces.

Even among normal subjects, subtle alterations in foot, ankle, and lower leg postures and kinematics affected mean peak heel forces during forward and backward walking. The presence of these relationships in normal subjects and probable exaggeration after injury should be of concern to athletic trainers as they treat lower extremity injuries, apply protective bracing or taping, and recommend footwear.

Similar assessments of common sport-relevant and position-relevant movements such as forward-running and backward-running directional changes (including diagonals), sudden stops and starts, and jumping may more realistically simulate the heel forces related to athletic lower extremity injuries. Further analysis should include timing and duration variables for mean peak heel forces and pressures, particularly in assessing the functional effects of taping and padding applications and other orthoses.

REFERENCES

1. Magee DJ. *Orthopedic Physical Assessment.* 2nd ed. Philadelphia, PA: WB Saunders; 1992.
2. Scott SH, Winter DA. Internal forces of chronic running injury sites. *Med Sci Sports Exerc.* 1990;22:357–369.
3. Cowan DN, Jones BH, Frykman PN, et al. Lower limb morphology and risk of overuse injury among male infantry trainees. *Med Sci Sports Exerc.* 1996;28:945–952.
4. Reigger-Krugh C, Keysor JJ. Skeletal malalignments of the lower quarter: correlated and compensatory motions and postures. *J Orthop Sports Phys Ther.* 1996;23:164–170.
5. Eng JJ, Pierrynowski MR. The effect of soft foot orthotics on three-dimensional lower-limb kinematics during walking and running. *Phys Ther.* 1994;74:836–844.

6. Klingman RE, Liaos SM, Hardin KM. The effect of subtalar joint posting on patellar glide position in subjects with excessive rearfoot pronation. *J Orthop Sports Phys Ther.* 1997;25:185–191.
7. Nawoczenski DA, Cook TM, Saltzman CL. The effect of foot orthotics on three-dimensional kinematics of the leg and rearfoot during running. *J Orthop Sports Phys Ther.* 1995;21:317–327.
8. Radin EL, Yang KH, Riegger C, Kish VL, O'Connor JJ. Relationship between lower limb dynamics and knee joint pain. *J Orthop Res.* 1991;9:398–405.
9. Andrews M, Noyes FR, Hewett TE, Andriacchi TP. Lower limb alignment and foot angle are related to stance phase knee adduction in normal subjects: a critical analysis of the reliability of gait analysis data. *J Orthop Res.* 1996;14:289–295.
10. Subotnick SI. *Podiatric Sports Medicine*. Mount Kisco, NY: Futura Publishing; 1975.
11. McPoil TG, Cornwall MW. The relationship between static lower extremity measurements and rearfoot motion during walking. *J Orthop Sports Phys Ther.* 1996;24:309–314.
12. Cavanagh PR, Morag E, Boulton AJ, et al. The relationship of static foot structure to dynamic foot function. *J Biomech.* 1997;30:243–250.
13. Birke JA, Franks BD, Foto JG. First ray joint limitation, pressure, and ulceration of the first metatarsal head in diabetes mellitus. *Foot Ankle Int.* 1995;16:277–284.
14. Cipriani DJ, Armstrong CW, Gaul S. Backward walking at three levels of treadmill inclination: an electromyographic and kinematic analysis. *J Orthop Sports Phys Ther.* 1995;22:95–102.
15. Vilensky JA, Gankewicz E, Gehlsen G. A kinematic comparison of backward and forward walking in humans. *J Hum Movement Stud.* 1987;13:29–50.
16. Gray GW. *Chain Reaction Course Program*. Adrian, MI: Wynn Marketing, Inc; 1994.
17. Easley ME, Anderson RB. Hallux rigidus in the adult and adolescent. In: Adelaar RS, ed. *Disorders of the Great Toe*. Rosemont, IL: American Academy of Orthopaedic Surgeons; 1997:23–32.
18. Beckett ME, Massie DL, Bowers KD, Stoll DA. Incidence of hyperpronation in the ACL-injured knee: a clinical perspective. *J Athl Train.* 1992;27:58–62.
19. Loudon JK, Jenkins W, Loudon KL. The relationship between static posture and ACL injury in female athletes. *J Orthop Sports Phys Ther.* 1996;21:328–336.
20. Lehman JF, Esselman PC, Ko MJ, et al. Plastic ankle-foot orthoses: evaluation of function. *Arch Phys Med Rehabil.* 1983;64:402–407.
21. Opara CU, Levangie PK, Nelson DL. Effects of selected assistive devices on normal distance gait characteristics. *Phys Ther.* 1985;65:1188–1191.
22. Rose-Jacobs R. Development of gait at slow, free, and fast speeds in 3- and 5-year-old children. *Phys Ther.* 1983;63:1251–1259.
23. Smith-Oricchio K, Harris BA. Interrater reliability of subtalar neutral, calcaneal inversion and eversion. *J Orthop Sports Phys Ther.* 1990;12:10–15.
24. Hopson MM, McPoil TG, Cornwall MW. Motion of the first metatarsophalangeal joint: reliability and validity of four measurement techniques. *J Am Podiatr Med Assoc.* 1995;85:198–204.
25. Palmer ML, Epler M. *Clinical Assessment Procedures in Physical Therapy*. Philadelphia, PA: JB Lippincott; 1990.
26. Kendall FP, McCreary EK. *Muscles: Testing and Function.* Baltimore, MD: Williams & Wilkins; 1983.
27. *F-Scan User's Manual.* Boston, MA: Tekscan Inc; 1993.
28. Myers RH. *Classical and Modern Regression with Applications.* 2nd ed. Boston, MA: PWS-Kent Publishing; 1990.
29. Brosky JA, Hillesheim MT, Smith S. The calcaneal fat pad: intrinsic dysfunction as a cause of heel pain [abstract]. *J Orthop Sports Phys Ther.* 1998;27:92.

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Effect of Microcurrent Stimulation on Delayed-Onset Muscle Soreness: A Double-Blind Comparison

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Objective: To examine the efficacy of microcurrent electrical neuromuscular stimulation (MENS) treatment on pain and loss of range of motion (ROM) associated with delayed-onset muscle soreness (DOMS).

Design and Setting: We assigned subjects to 1 of 2 groups. Group 1 received treatment with microcurrent stimulation (200 μA, 30 Hz, for 10 minutes, then 100 μA, 0.3 Hz, for 10 minutes) 24, 48, and 72 hours after DOMS induction. Group 2 served as a sham group and was treated using a machine altered by the manufacturer so that no current could flow through the electrodes.

Subjects: DOMS was induced in the biceps brachii of the nondominant arm of 18 subjects (3 males, 15 females: age = 20.33 ± 2.3 years, ht = 170.81 ± 7.3 cm, wt = 69.61 ± 13.1 kg). Dominance was defined as the arm used by the subject to throw a ball.

Measurements: Subjective pain and active elbow extension ROM were evaluated before and after treatment each day. Two methods were used to assess pain: constant pressure using a weighted Orthoplast sphere and full elbow extension to the limit of pain tolerance. Subjective pain was measured with a graphic rating scale and active elbow extension ROM using a standard, plastic, double-armed goniometer. Three repeated-measures ANOVAs (between-subjects variable was group, within-subjects variables were day and test) were used to assess ROM and pain scores for the 2 groups.

Results: We found no significant difference in the measurement of subjective pain scores or elbow extension ROM when the MENS group was compared with the sham group.

Conclusions: Our results indicate that the MENS treatment, within the parameters used for this experiment, was not effective in reducing the pain or loss of ROM associated with delayed-onset muscle soreness.

Key Words: electrical stimulation, MENS, DOMS, graphic rating scale

Electrical stimulation is a modality frequently used by athletic trainers in the treatment of symptoms (such as pain, swelling, loss of range of motion [ROM], and spasm) that are commonly associated with musculoskeletal trauma.[1] Recently, microcurrent stimulation has received attention as another type of electrotherapeutic modality capable of providing the beneficial effects commonly associated with the more classical forms of electrical stimulation.[2] Microcurrent electrical neuromuscular stimulation (MENS) is a subsensory modality that employs current intensities between 1 and 999 μA. It has been successfully used to enhance soft tissue healing[3–5] and to treat fracture nonunions.[6] The efficacy of microcurrent stimulation in the treatment of these conditions has led some clinicians to suggest that it might also be valuable in the treatment of musculoskeletal injury. Although MENS is used in the sports medicine setting, controlled, scientific studies documenting its efficacy are lacking. The purpose of our study was to examine the effect of microcurrent stimulation on pain and decreased ROM associated with delayed-onset muscle soreness (DOMS) using a double-blind research design.

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METHODS

Subjects

Eighteen subjects (3 males, 15 females: age = 20.33 ± 2.3 years, ht = 170.81 ± 7.3 cm, wt = 69.61 ± 13.1 kg) volunteered to participate in this study. None of the subjects were involved in any type of weight-lifting regimen. Subjects were asked to avoid any treatment other than the prescribed microcurrent treatment during their participation in the study. The procedures for this study were approved by a university institutional review board, and each subject provided informed consent.

Procedures

We assigned subjects to 1 of 2 groups. Group 1 served as the treatment group and received microcurrent stimulation (MENS

2000, Monad Corp, Pomona, CA). Group 2 served as the sham group and received treatment from a microcurrent unit that had been disabled by the manufacturer to provide no electrical stimulation. During the initial testing session, we assessed subjects for pain and elbow extension ROM. After this initial assessment, DOMS was induced. Subjects returned at 24-hour intervals for 3 days (days 2 through 4).

To ensure the blind nature of the study, neither experimenters nor subjects knew which microcurrent unit was the sham unit until the study was completed. Also, we asked subjects to refrain from commenting on any sensations experienced during treatment unless they felt pain or discomfort.

Range of Motion

We measured active elbow extension ROM using a standard, plastic, double-armed goniometer (Jamar, Clifton, NJ) with the subjects supine on a table and a towel roll just proximal to the elbow of the affected arm. The goniometer was aligned proximally with the head of the humerus and distally with the radial styloid. Elbow ROM was measured as subjects extended their elbows into a relaxed position.

Delayed-Onset Muscle Soreness

After initial evaluation for pain and ROM, DOMS was induced in the nondominant biceps brachii of each subject. The protocol for inducing DOMS has been previously described and proved effective.[7–12] Male subjects began with a 13.5-kg (30-lb) dumbbell, whereas female subjects began with an 11.25-kg (25-lb) dumbbell. Beginning in full elbow flexion, subjects were instructed to lower the dumbbell to full extension over 3 seconds. Upon reaching full extension, the primary investigator assisted the subjects in returning the weight to the starting position. Subjects performed continuous repetitions until they could no longer control the weight during the 3-second period. At this point, the weight was reduced by 2.25 kg (5 lb), and the protocol was repeated. As subjects continued to fatigue, the weight was sequentially lowered in 2.25-kg (5-lb) increments until a total weight of 2.25 kg (5 lb) was reached. At this weight, subjects were asked to perform repetitions either to fatigue or until 10 repetitions were completed.

Treatment

Subjects returned to the testing site 24, 48, and 72 hours after the initial treatment session. A 5.08 × 10.16-cm (2 × 4-in) pad was attached to the positive electrode and placed over the belly of the biceps brachii. A 5.08 × 5.08-cm (2 × 2-in) pad was placed posteriorly over the belly of the triceps brachii. Subjects received a 20-minute treatment. For those subjects receiving the MENS treatment, the intensity for the first 10 minutes was set at 200 μA and the frequency at 30 Hz. After 10 minutes, the intensity and frequency were lowered to 100 μA and 0.3 Hz, respectively.

Pain Assessment

Pain was assessed using a graphic rating scale (GRS).[13] The scale consisted of a horizontal axis with verbal descriptors of pain intensity placed at equal distances along the length (Figure 1). Subjects were asked to place a vertical line at the point on the scale that best described their pain. The distance from the left side of the scale to this mark was measured in centimeters.

Pain was elicited in 2 ways. For the first pain measurement, pain was recorded as constant pressure was exerted on the belly of the muscle. A 5.08-cm (2-in) diameter sphere constructed from Orthoplast (Johnson & Johnson, Pittsburgh, PA) was glued to a 10 × 10-cm (4 × 4-in) square of the same material (Figure 2). A 2.25-kg (5-lb) ankle weight was attached to the Orthoplast sphere. After pilot testing, a 2.25-kg (5-lb) ankle weight was found to have adequate mass to elicit discomfort. Each subject was seated with the arm resting on a table at 90° of horizontal shoulder abduction and 90° of elbow flexion. The Orthoplast sphere was looped over the belly of the biceps brachii, and the subject was asked to rate pain while the weight rested on the arm. For the second pain measurement, each subject was asked to rate pain while actively extending the elbow as far as possible. To limit the potential influence of pain, this measurement was taken after elbow extension ROM. Pain measurements were taken before and after DOMS induction and before and after treatment during subsequent sessions.

RESULTS

Three repeated-measures analyses of variance (the between-subjects variable was group and the within-subjects variables were day and test) were used to assess ROM and pain scores for the 2 groups. Increased ROM and decreased pain score indicate improvement after the treatment. Means and standard deviations for all conditions are presented in Tables 1–3. A

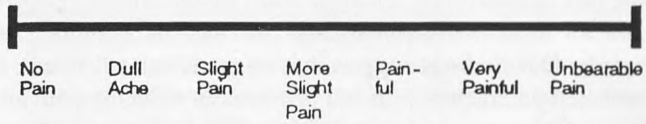

Figure 1. Graphic rating scale used for pain measurement.

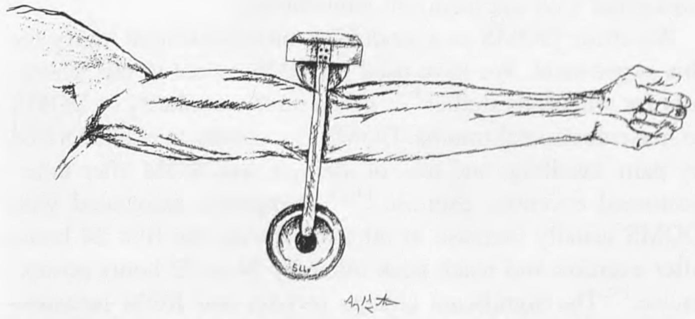

Figure 2. Orthoplast sphere and 2.25-kg (5-lb) weight used for compression during pain measurement.

Table 1. Means and Standard Deviations (degrees) for the ROM Condition for the MENS and Sham Groups Before (Pre) and After (Post) Treatment

	Day 1		Day 2		Day 3		Day 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
MENS								
Mean	3.89	−14.00	−20.89	−18.44	−28.00	−23.33	−23.78	−17.78
SD	7.21	13.52	14.93	15.19	14.35	24.62	13.47	17.50
Sham								
Mean	−0.44	−23.44	−25.22	−24.22	−36.44	−33.00	−30.00	−28.00
SD	12.30	16.05	21.86	24.12	22.62	23.13	23.83	19.10

Table 2. Means and Standard Deviations (cm) for the Extension Condition for the MENS and Sham Groups Before (Pre) and After (Post) Treatment

	Day 1		Day 2		Day 3		Day 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
MENS								
Mean	0.39	1.27	3.54	3.74	4.65	3.93	2.63	2.21
SD	0.31	1.20	1.78	2.09	2.99	2.91	1.62	1.73
Sham								
Mean	0.41	1.56	3.47	3.00	4.59	4.31	3.20	3.16
SD	0.25	1.95	1.71	1.54	1.56	1.40	1.99	2.11

Table 3. Means and Standard Deviations (cm) for the Orthoplast Sphere Condition Measured for the MENS and Sham Groups Before (Pre) and After (Post) Treatment

	Day 1		Day 2		Day 3		Day 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
MENS								
Mean	1.47	1.28	3.23	2.89	4.11	3.58	1.44	1.61
SD	1.87	1.06	2.65	2.08	3.41	3.12	0.57	1.32
Sham								
Mean	0.90	1.61	3.02	3.33	3.85	3.36	2.34	2.07
SD	0.70	1.85	2.01	2.21	1.61	1.54	2.07	1.62

significant main effect for day was found for all measurements: GRS-Orthoplast sphere ($F_{3,48}$ = 44.26, P = .001), GRS-extension ($F_{3,48}$ = 18.62, P = .001), and ROM ($F_{3,48}$ = 13.40, P = .001). A significant day-by-test interaction was found for GRS extension ($F_{3,48}$ = 5.04, P = .004) and ROM scores ($F_{3,48}$ = 19.77, P = .001). No significant differences were found for any of the group-by-test interactions: GRS-Orthoplast sphere ($F_{1,16}$ = 0.74, P = .402), GRS-extension ($F_{1,16}$ = 0.14, P = .717), and ROM ($F_{1,16}$ = 0.96, P = 3.42).

DISCUSSION

The lack of controlled scientific study on the effectiveness of MENS for musculoskeletal trauma provided the rationale for this study. Our findings suggest that microcurrent treatment, at the selected parameters, was not effective in reducing pain and loss of ROM associated with DOMS. The lack of significant differences for pain and ROM scores between the treatment and sham groups also suggests the lack of placebo effect associated with microcurrent stimulation.

We chose DOMS as a model for musculoskeletal injury for this experiment. We have used a DOMS model in our laboratory for numerous studies[7–12] based on the similarity of DOMS to musculoskeletal trauma. DOMS is a condition characterized by pain, swelling, and loss of strength and ROM after unaccustomed eccentric exercise.[14,15] Symptoms associated with DOMS usually increase in intensity during the first 24 hours after exercise and reach peak intensity 24 to 72 hours postexercise.[15] The significant change in pain and ROM measurements between days indicates that the protocol used in this experiment effectively induced DOMS.

In previous DOMS studies, pain measurements have generally been collected as subjects actively extended the involved extremity as far as possible. The distinct loss of ROM associated with DOMS makes this task quite uncomfortable and provides 2 reasons for avoiding such a procedure. First, active elbow extension stretches the muscle, thereby affecting subsequent ROM measurements, and second, the discomfort created by active elbow extension could inhibit subsequent ROM. ROM measurements taken before pain measurements could also affect pain ratings. To avoid these effects, we chose to measure pain using the Orthoplast sphere before ROM measurements and then obtained a second pain measurement using active elbow extension immediately after ROM measurement.

Much of the support for the use of microcurrent stimulation on musculoskeletal trauma is purely testimonial. Recently, researchers have begun experimenting with this modality to investigate its efficacy in musculoskeletal trauma. Their findings provide conflicting data. Denegar et al[8] found that microcurrent treatment (100 μA at 0.3 Hz for 20 minutes) provided transient analgesia but did not significantly reduce the loss of strength associated with DOMS. Maurer et al[16] reported less reduction in ROM after treatment with microcurrent stimulation at individual subsensory levels but concluded that MENS was not effective overall in the treatment of DOMS. Weber et al[14] reported no significant difference among MENS, massage, upper body ergometry, and control treatments on DOMS. Finally, Rapaski et al[17] found that MENS treatment at an intensity of 100 μA and individual subsensory levels was effective in reducing postexercise creatine kinase levels after the induction of DOMS.

Previous authors have reported enhanced soft tissue healing[3–5] and treatment of fracture nonunions[6] after subsensory electrostimulation. Direct current stimulation was used in all 3 studies[3–5] and alternating current in only one.[3] Bach et al[3] examined the biochemical and biomechanical effects of direct and alternating current subsensory stimulation on the healing of skin incisions. They reported an increase in collagen concentration in and around the wound (biochemical effect) and no difference in the tensile strength or wound thickness (biomechanical effects) when compared with control groups. MENS was delivered via an alternating current in our study. Therefore, the biochemical increases in collagen formation after MENS are advantageous but may not be reflected when clinical measures such as ROM and subjective pain measures are used. The conflicting results of the aforementioned studies demonstrate the need for further investigation of the efficacy of microcurrent stimulation before we can use it confidently as a treatment for musculoskeletal trauma. Further research should address the efficacy of specific treatment parameters, including current, intensity, frequency, and treatment times, so that clinical applications can be identified.

CONCLUSIONS

At the parameters selected for this experiment, microcurrent stimulation was not effective in reducing pain and loss of ROM associated with DOMS. Additional research is needed before we can use microcurrent stimulation confidently in the sports medicine setting to reduce pain after musculoskeletal injury.

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REFERENCES

1. Prentice WE. *Therapeutic Modalities in Sports Medicine.* 2nd ed. St. Louis, MO: Times Mirror/Mosby College; 1990.
2. Picker RI. Low-volt pulsed microamp stimulation: part I. *Clin Man.* 1989a;9:28–33.
3. Bach S, Bilgrav K, Gottrup F, Jorgensen TE. The effect of electrical current on healing skin incision: an experimental study. *Eur J Surg.* 1991;157:171–174.
4. Carley PJ, Wainapel SF. Electrotherapy for acceleration of wound healing: low intensity direct current. *Arch Phys Med Rehabil.* 1985;66:443–446.
5. Nessler JP, Mass DP. Direct-current stimulation of tendon healing in vitro. *Clin Orthop.* 1987;217:303–312.
6. Brighton CT, Friedenberg ZB, Mitchell EI, Booth RE. Treatment of nonunion with constant direct current. *Clin Orthop.* 1977;124:106–123.
7. Mattacola CG, Perrin DH, Gansneder BM, Allen JD, Mickey CA. A comparison of visual analog scale and graphic rating scales for pain intensity following delayed onset muscle soreness. *J Sport Rehabil.* 1997;6:38–46.
8. Denegar CR, Yoho AP, Borowicz AJ, Bifulco N. The effects of low-volt microamperage stimulation on delayed onset muscle soreness. *J Sport Rehabil.* 1992;1:95–102.
9. Schmitz RJ, Martin DE, Perrin DH, Iranmanesh A, Rogol AD. Effect of interferential current on perceived pain and serum cortisol associated with delayed onset muscle soreness. *J Sport Rehabil.* 1997;6:30–37.
10. Grossman JM, Arnold BA, Perrin DH, Kahler DM. Effect of ibuprofen on pain, decreased range of motion, and decreased strength associated with delayed onset muscle soreness of the elbow flexors. *J Sport Rehabil.* 1995;4:253–263.
11. Denegar CR, Perrin DH. Effect of transcutaneous electrical nerve stimulation, cold, and a combination treatment on pain, decreased range of motion, and strength loss associated with delayed onset muscle soreness. *J Athl Train.* 1992;27:200–206.
12. Haynes SC, Perrin DH. Effect of a counterirritant on pain and restricted range of motion associated with delayed onset muscle soreness. *J Sport Rehabil.* 1992;1:13–18.
13. Denegar, CD, Perrin DH, Rogol A, Rutt R. Influence of transcutaneous electrical nerve stimulation on pain, range of motion, and serum cortisol concentration in females experiencing delayed onset muscle soreness. *J Orthop Sports Phys Ther.* 1989;11:100–103.
14. Weber MD, Servedio FJ, Woodall WR. The effects of three modalities on delayed onset muscle soreness. *J Orthop Sports Phys Ther.* 1994;20:236–242.
15. Armstrong RB. Mechanisms of exercise-induced delayed onset muscle soreness: a brief review. *Med Sci Sports Exerc.* 1984;16:529–538.
16. Maurer CL, Miller RS, Peterson BR, Welper LM, Barr JO, Miller BA. The effectiveness of microelectrical neural stimulation (MENS) on exercise-induced muscle trauma. *Phys Ther.* 1992;72:S74.
17. Rapaski D, Isles S, Kulig K, Boyce D. Microcurrent electrical stimulation: a comparison of two protocols in reducing delayed onset muscle soreness *Phys Ther.* 1991;71:S116.

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Serum Dexamethasone Levels After Decadron Phonophoresis

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Objective: To determine serum levels of dexamethasone at several intervals after administration of Decadron (dexamethasone sodium phosphate) phonophoresis.

Design and Setting: This study was designed as a 2-factor analysis of variance with repeated measures on 1 factor (blood draws). Independent variables were group (gel/sham, gel/ultrasound, dexamethasone/sham, dexamethasone/ultrasound) and blood draws (pretreatment, posttreatment, 15 minutes, and 30 minutes). The dependent variable was the serum level of dexamethasone.

Subjects: Forty healthy college students (21 males, 19 females; mean age = 22 ± 1.3 years) with no known drug allergies or current medication use were randomly assigned to 1 of 4 treatment groups. The treatment site was the left forearm.

Measurements: After the pretreatment blood draw, a 10-minute ultrasound treatment was administered, followed by a posttreatment blood draw. Two additional blood draws followed at 15-minute intervals. A total of 4 serum samples (5 cc each) from each subject were centrifuged, and the pipetted serum was frozen for later analysis by double antibody radioimmunoassay.

Results: No significant amounts of serum dexamethasone were detected in 12 consecutive samples. Testing of additional samples was, therefore, discontinued.

Conclusions: Decadron phonophoresis as used in this experiment did not result in detectable serum levels of dexamethasone. More study is needed to validate the efficacy of Decadron phonophoresis on serum dexamethasone levels.

Key Words: corticosteroid, ultrasound, serum analysis

Phonophoresis uses ultrasound to enhance the absorption of topically applied drugs into underlying tissue, offering an alternative to injection or oral administration of medication. Previous researchers have reported contradictory findings as to the efficacy of this procedure.[1–5] There are 2 main factors that affect phonophoresis: the medium and the ultrasound administration.

For phonophoresis application, ultrasound gel is commonly mixed with anti-inflammatory medications, counterirritants, and anesthetics. If a medium is not a good transmitter of ultrasound energy, then it is impossible to achieve the desired phonophoretic effects. Many previous studies on phonophoresis,[1–3,6–10] as well as more current modality texts,[11–14] used or advocated the use of hydrocortisone preparations. In 1992, Cameron and Monroe[4] measured the transmission qualities of different phonophoretic media and determined that hydrocortisone preparations were poor transmitters of acoustical energy. Studies using hydrocortisone preparations as the medium, therefore, cannot be used to determine the efficacy of phonophoresis. It is our observation that many clinicians now use dexamethasone sodium phosphate, or Decadron (Merck & Co, Inc, West Point, PA), in their phonophoretic treatment as an alternative to hydrocortisone. Decadron is an injectable corticosteroid that, when mixed with ultrasound transmission gel, has been shown to be an effective transmitter of ultrasound energy.[15] Few studies, however, have been conducted to test the efficacy of Decadron phonophoresis.

The administration of phonophoresis, with specific reference to the ultrasound parameters, has been a second source of confusion in the literature. Wide ranges in the settings of frequency, intensity, duration, and mode have been used without any justification. Recent studies suggest continuous mode ultrasound[16–19] at a frequency of 1 MHz[19–21] and an intensity of 1.0 W/cm^2 for 10 minutes[7,22] as the parameters of choice for effective phonophoresis. We have, however, found no studies that have attempted to measure the presence of dexamethasone after Decadron phonophoresis using currently suggested parameters. Our purpose, therefore, was to determine how the administration of Decadron phonophoresis on continuous mode ultrasound at 1 MHz frequency and 1.0 W/cm^2 for 10 minutes affected serum levels of dexamethasone.

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METHODS

This randomized, double-blind, clinical study measured the effect of 2 independent variables (factors) on 1 dependent variable. The dependent variable was serum dexamethasone level. The independent variables were group (gel/sham, gel/

ultrasound, Decadron/sham, Decadron/ultrasound) and blood draws (pretreatment, posttreatment, 15 minutes, and 30 minutes).

Subjects

Forty college students (21 males, 19 females), of mean age 22 ± 1.3 years, initially participated in the study. Subjects were restricted to those not currently taking any medication, with no known drug allergies, and with no recent history of ecchymosis, infection, swelling, or injury to the treatment site. The left forearm was selected because of its proximity to the antecubital fossa with accompanying antecubital veins. The study was sanctioned by the Brigham Young University Institutional Review Board, which also approved the consent form signed by each subject.

Instruments

The ultrasound unit used was the Omnisound 3000 (Accelerated Care Plus-Physio Technology Inc, Topeka, KS). The generator operates at frequencies of either 1 or 3 MHz. The transducer surface area is 5 cm^2 with an effective radiating area (ERA) of 4.5 cm^2, meaning that nearly all of the transducer's surface transmits acoustic energy. The beam nonuniformity ratio of 1.8:1 allows treatment at higher average output intensities with reduced risk of localized tissue heating, periosteal damage, and transient cavitation.

We used Ultra Phonic ultrasound transmission gel (Pharmaceutical Innovations Inc, Newark, NJ) in the control groups and a mixture of Decadron and Ultra Phonic gel for the treatment groups. The Decadron/gel mixture was prepared by a licensed pharmacist who routinely mixes media for phonophoretic use. Both media were used at room temperature (25°C) to replicate the clinical setting. Blood samples were centrifuged using a Beckman Model TJ-6 Centrifuge (Beckman Instruments, Inc, Palo Alto, CA).

Procedures

Each subject cleaned the left forearm with soap and water and lay supine on a treatment table. To restrict all treatment areas to the same size, we placed a 2-ERA template 4 cm distal to the midline of the antebrachial fossa on the left forearm. Using sterile technique, a registered nurse inserted an 18-gauge angiocath into an antecubital fossa vein proximal to the treatment area. The angiocath remained in place during the entire session to allow for subsequent blood draws. A 5-cc pretreatment blood sample was drawn, and the line was flushed with 2 cc normal saline to maintain patency.

Using a table of random numbers, each subject was randomly assigned to 1 of 4 groups. Treatment A used 100% Ultra Phonic ultrasound transmission gel with sham ultrasound (the machine turned off). Treatment B subjects received continuous ultrasound at 1 MHz, 1.0 W/cm^2, for 10 minutes with gel. Treatment C subjects received sham ultrasound coupled with Decadron/gel mixture (16.65 mg dexamethasone/100 mL gel). Treatment D subjects received continuous ultrasound at 1 MHz, 1.0 W/cm^2, coupled with Decadron in gel. The treatment media were in coded, identical bottles, and the ultrasound administrator was unaware of the assigned treatment group. In each instance, 3 cc of the ultrasound couplant was applied to the treatment area, approximating 2 mm in thickness. The sound head was moved back and forth within the template at approximately 3–4 cm/s.

Immediately following the ultrasound treatment, saline was withdrawn from the catheterized line and discarded, and a 5-cc posttreatment blood sample was drawn. The line was flushed a second time with 2 cc normal saline. The third blood sample was obtained 15 minutes posttreatment using the same method. Thirty minutes after the treatment, saline was withdrawn for the last time, and the final 5-cc blood sample was taken. The angiocath was removed, the area cleansed with 70% isopropyl alcohol, and a bandage applied to the injection site.

All blood samples were centrifuged within 1 hour at a relative force of 2500*g* for 20 minutes. The serum was pipetted, placed in 5-cc aliquot tubes, and immediately frozen at −30°C for later analysis. All samples were coded to ensure that laboratory personnel were unaware of the experimental conditions for each sample.

Analysis

The samples were analyzed using a double antibody radioimmunoassay.[23] The assay consisted of 3 parts. The first step used a known amount of radioactive dexamethasone ("hot" dexamethasone) and paper chromatography to separate dexamethasone from other similar steroids in the blood, such as cortisol. The second used an antibody, developed in rabbits, that binds to both the hot and cold dexamethasone. The third step employed a second antibody, goat anti-rabbit γ-globulin, that binds to the first antibody and the accompanying bound dexamethasone. The remaining amount of hot dexamethasone is counted in a scintillation counter. The count of free hot dexamethasone is correlated with the amount of serum dexamethasone. The sensitivity of the assay to dexamethasone is 50 ng/dL (10^{-9} g/dL); hence, the assay would show if 0.5% of the 0.48 mg of dexamethasone placed on the skin penetrated to the serum.

Statistics

We initially planned to use a 2-way analysis of variance with repeated measures on 1 factor to analyze the data. There were 4 levels of the between-subjects factor (group): treatments A, B, C, and D. The second independent variable (multiple blood draws pretreatment, posttreatment, and at 15 and 30 minutes) was the repeated-measures or within-subjects factor. The dependent variable was the measured level of dexamethasone in the serum. The criterion for significance was set at $P < .05$.

RESULTS

The first 8 experimental samples analyzed (2 samples from treatment A subjects and 6 samples from treatment D subjects) showed no detectable level of serum dexamethasone (<50 ng/dL). Thus, due to the absence of serum dexamethasone in 8 consecutive treatment samples, testing of additional samples was discontinued by the laboratory. In order to verify the results of the analysis performed at our institution, 4 additional samples from treatment D subjects were analyzed by Endocrine Sciences, Inc (Calabasas Hills, CA). The values were reported as <30 ng/dL (10^{-9} g/dL). The sensitivity of the assays to dexamethasone in serum are 50 ng/dL and 30 ng/dL, respectively; hence, anything less than those values assumes an operational definition of 0. Because all of the samples were reported as less than the sensitivity of the measure, the need to perform additional analyses was deemed unnecessary.

DISCUSSION

To date, the question of the effectiveness of phonophoresis in driving corticosteroids into the body remains unanswered. Many of the previous studies suffered from flaws in methodology, in choice of media, or in use of ultrasound parameters that bring into question the researchers' conclusions concerning the efficacy of phonophoresis.

Griffin and colleagues[1,2,6–8] performed a series of studies investigating hydrocortisone phonophoresis in swine. The reported increase in cortisol levels in skeletal and nervous tissue was not necessarily a result of the treatment, because the skin surface was burned[1,8] and the animals were manually restrained before they were anesthetized.[1,2] Either of these conditions could account for an increase in cortisol levels, since a disruption in the skin surface would allow for increased cortisol penetration and, as speculated by the authors,[7] the stress of the manual restraint would cause an outpouring of cortisol from the adrenal cortex.

Three later studies using the human forearm as a treatment site supplied additional information, yet still suffered from methodologic problems. Benson et al[16] used a medium found to be transmissive to ultrasound; however, the back-diffusion technique for measuring drug absorption used for the first time in this study was reported to be an inefficient method of measurement. Oziomek et al[17] and Bare et al[5] attempted to measure serum levels of trolamine salicylate (Myoflex, Bayer Inc, Toronto, Ontario, Canada) and 10% hydrocortisone, respectively. Both of these media, however, were identified by Cameron and Monroe[4] as poor transmitters of ultrasound.

Many of these recent studies seem to show that phonophoresis is not effective. Because of flaws in methodology, however, they cannot be used to evaluate phonophoresis efficacy. One recent study on mini Yucatan pigs, conducted by Byl et al in 1993,[15] lends credit to phonophoresis. Collagen deposition was measured in response to the following treatments. Hydrocortisone acetate and dexamethasone were applied by rubbing, injecting, or sonating (ultrasounding) the drug mixed with ultrasound gel (1 MHz, 1.5 W/cm^2, for 5 minutes). They tested the ultrasound transmission quality of the sonating mixtures and found that the dexamethasone mixture ranged from 95% to 98%, whereas the hydrocortisone mixture was recorded at less than 1%. They reported significant effects of the sonated dexamethasone, the injected dexamethasone, and the injected hydrocortisone, but not the sonated hydrocortisone. Because of its excellent transmission quality and seemingly positive outcome, we used a similar mixture of Decadron and gel.

One additional study using Decadron produced favorable results. Relief from trigger-point pain was reported in 88% of patients treated with Decadron and lidocaine phonophoresis, whereas a control group receiving the same medium via sham ultrasound reported only 23% relief.[24] It cannot be concluded, however, whether the results were due to the Decadron or lidocaine alone or the combination of the 2.

Our research employed a medium known to transmit ultrasound well and employed appropriate ultrasound parameters, yet our results did not support the use of phonophoresis. There are several possible reasons.

Phonophoresis may be ineffective, and ultrasound may not enhance the absorption of topically applied drugs into underlying tissue. We are not convinced that this is the case. In the Byl et al study[15] on mini Yucatan pigs using 2 corticosteroids (hydrocortisone acetate and dexamethasone), the fact that there was a decrease in collagen deposition with the sonated dexamethasone indicates its presence. There are several possibilities as to why we did not detect it.

It is possible that, after the drug is absorbed through the skin, it is sequestered in the subcutaneous tissue. Therefore, it would not be present in serum until a later time, since it is slowly released. A second finding from Byl et al[15] supports this idea. Reduced collagen deposition after dexamethasone phonophoresis was measured in the subcutaneous tissue, but not in the submuscular or subtendinous tissue. The inclusion of a later blood draw, perhaps 12 to 24 hours after the treatment, might have been appropriate to investigate the possibility of slow release of the drug from the subcutaneous tissue. Unfortunately, an error in the analysis of our pilot data led us to believe that the levels of serum dexamethasone peaked 15 minutes after the administration of Decadron phonophoresis. Therefore, our blood samples were drawn at pretreatment, posttreatment, 15 minutes, and 30 minutes.

It may be that the injectable form of Decadron we administered does not show up in the assays we used. After an extensive review of available assays, we found no assay specific to Decadron. However, we did identify a double antibody radioimmunoassay to test for serum dexamethasone.[23] Since dexamethasone is the active ingredient of Decadron, we chose this assay to test the absorption of Decadron. Although the analysis of pilot data appeared to demonstrate the effectiveness of the testing procedure and the accuracy of the assay when used with Decadron, analysis of subsequent samples showed no presence of serum dexamethasone. In order to examine the discrepancy between the pilot data and the first 8 samples tested, we sent 4 additional samples to an outside laboratory. The assay that the outside laboratory performed differed only in that it did not use the second antibody, but rather ammonium sulfate precipitation, to separate the bound and free dexamethasone. That laboratory also reported no presence of serum dexamethasone. On additional review of the pilot data, we found errors in the analysis that resulted in the false-positive appearance of serum dexamethasone in the pilot data. Both radioimmunoassays are generally used to analyze serum after an oral dose of dexamethasone. In injectable Decadron, a phosphate group is attached to the 21-carbon, which may interfere with the binding of the antibody in the first step of the assay. If this is the case, neither assay would recognize the phosphorylated dexamethasone.

CONCLUSIONS

Our study showed no levels of dexamethasone in serum after Decadron phonophoresis in 12 samples. We advocate the need for further research using an appropriate medium and appropriate ultrasound parameters before a conclusion can be drawn concerning the efficacy of phonophoresis. Future research should employ the following: tissue biopsy of the subcutaneous tissue, use of a different form of dexamethasone with one of the described assays, or use of a different radioimmunoassay specific to Decadron.

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REFERENCES

1. Griffin JE, Touchstone JC. Ultrasonic movement of cortisol into pig tissue, I: movement into skeletal muscle. *Am J Phys Med.* 1963;42:77–85.
2. Griffin JE, Touchstone JC, Liu AC-Y. Ultrasonic movement of cortisol into pig tissue, II: movement into peripheral nerve. *Am J Phys Med.* 1965;44:20–25.
3. Davick JP, Martin RK, Albright JP. Distribution and deposition of tritiated cortisol using phonophoresis. *Phys Ther.* 1988;68:1672–1675.
4. Cameron MH, Monroe LG. Relative transmission of ultrasound by media customarily used for phonophoresis. *Phys Ther.* 1992;72:142–148.
5. Bare AC, McAnaw MB, Pritchard AE, et al. Phonophoretic delivery of 10% hydrocortisone through the epidermis of humans as determined by serum cortisol concentrations. *Phys Ther.* 1996;76:738–749.
6. Griffin JE, Echternach JL, Price RE, Touchstone JC. Patients treated with ultrasonic driven hydrocortisone and with ultrasound alone. *Phys Ther.* 1967;47:594–601.
7. Griffin JE, Touchstone JC. Low-intensity phonophoresis of cortisol in swine. *Phys Ther.* 1968;48:1336–1344.
8. Griffin JE, Touchstone JC. Effects of ultrasonic frequency on phonophoresis of cortisol into swine tissues. *Am J Phys Med.* 1972;51:62–78.
9. Kleinkort JA, Wood F. Phonophoresis with 1 percent versus 10 percent hydrocortisone. *Phys Ther.* 1975;55:1320–1324.
10. Wing M. Phonophoresis with hydrocortisone in the treatment of temporomandibular joint dysfunction. *Phys Ther.* 1982;62:32–33.
11. Roy S, Irvin R. *Sports Medicine: Prevention, Evaluation, Management, and Rehabilitation.* Englewood Cliffs, NJ: Prentice-Hall, Inc; 1983:100.
12. American Academy of Orthopaedic Surgeons. *Athletic Training and Sports Medicine.* 2nd ed. Park Ridge, IL: American Academy of Orthopaedic Surgeons; 1991:488–489.
13. Hecox B, Mehreteab TA, Weisberg J. *Physical Agents: A Comprehensive Text for Physical Therapists.* Norwalk, CT: Appleton Lange; 1994:175.
14. Arnheim DD, Prentice WE. *Principles of Athletic Training.* 9th ed. St. Louis, MO: McGraw-Hill Companies, Inc; 1997:327.
15. Byl NN, McKenzie A, Halliday B, Wong T, O'Connell J. The effects of phonophoresis with corticosteroids: a controlled pilot study. *J Orthop Sports Phys Ther.* 1993;18:590–600.
16. Benson HAE, McElnay JC, Harland R. Use of ultrasound to enhance percutaneous absorption of benzydamine. *Phys Ther.* 1989;69:113–118.
17. Oziomek RS, Perrin DH, Herold DA, Denegar CR. Effect of phonophoresis on serum salicylate levels. *Med Sci Sports Exerc.* 1991;23:397–401.
18. Mitragotri S, Blankschtein D, Langer R. Ultrasound-mediated transdermal protein delivery. *Science.* 1995;269:850–853.
19. Mitragotri S, Edwards DA, Blankschtein D, Langer R. A mechanistic study of ultrasonically-enhanced transdermal drug delivery. *J Pharm Sci.* 1995;84:697–706.
20. Williams AR, Rosenfeld EH, Williams KA. Gel-sectioning technique to evaluate phonophoresis *in vitro. Ultrasonics.* 1990;28:132–136.
21. Bommannan D, Okuyama H, Stauffer P, Guy RH. Sonophoresis, I: the use of high-frequency ultrasound to enhance transdermal drug delivery. *Pharm Res.* 1992;9:559–564.
22. Bommannan D, Menon GK, Okuyama H, Elias PM, Guy RH. Sonophoresis, II: examination of the mechanism(s) of ultrasound-enhanced transdermal drug delivery. *Pharm Res.* 1992;9:1043–1047.
23. Meikle AW, Lagerquist LG, Tyler FH. A plasma dexamethasone radioimmunoassay. *Steroids.* 1973;22:193–202.
24. Moll MJ. A new approach to pain: lidocaine and Decadron with ultrasound. *USAF Med Serv Digest.* 1979;30:8–11.

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The Effect of Hip Position and Electromyographic Biofeedback Training on the Vastus Medialis Oblique: Vastus Lateralis Ratio

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Objective: Patellofemoral pain syndrome is a patellar tracking dysfunction usually associated with vastus medialis oblique (VMO) weakness, and subsequently, a small VMO:vastus lateralis (VL) ratio. Several early electromyographic (EMG) studies have defined specific limb positions (such as external rotation of the hip) that preferentially activate the VMO. However, whether preferential activation of the VMO successfully translates into increased VMO:VL ratios with training has not been investigated. The purpose of our study was to investigate the effects of hip rotation on the mean VMO:VL EMG ratio using EMG biofeedback training over a 5-day period.

Design and Setting: Subjects performed isometric quadriceps contractions, in terminal extension, in 1 of 3 hip positions: the anatomically neutral hip position (group A), external hip rotation (group B), and internal hip rotation (group C). Pretest to posttest data were analyzed with a 3 (group) × 2 (test) analysis of variance with repeated measures on the last factor.

Subjects: Thirty-six healthy female college students with no known right knee musculoskeletal dysfunction.

Measurements: Activity of the VMO and VL was recorded by EMG and reported as the VMO:VL ratio.

Results: The main effect for group was not significant, but the main effect for test was significant. No significant interaction between group and test was noted.

Conclusions: The statistical analysis of our results suggests that hip position during EMG biofeedback training has no effect on the VMO:VL ratio. However, because subjects were able to significantly increase their VMO:VL ratio in 5 days regardless of hip position, EMG biofeedback can be recommended for the facilitation of VMO muscular recruitment.

Key Words: patellofemoral, biofeedback

Patellofemoral pain syndrome (PFPS) is one of the most frequent knee pathologies seen in orthopaedic practice.[1–5] This disorder is commonly associated with an imbalance between the vastus medialis oblique (VMO) and the vastus lateralis (VL) muscles. PFPS patients typically exhibit a marked decrease in VMO activity,[4,6,7] decreasing the ability of the VMO to produce medial patellar forces to counteract the lateral forces produced by the VL.[4,8–10] For this reason, reestablishing balance between the VMO and VL is the primary goal of PFPS rehabilitation programs.

Theoretically, improving the VMO:VL ratio could be accomplished by selectively training the VMO to increase its activity in relation to the VL.[3,11–15] Further, if a particular modification, such as hip position, were known to affect VMO and VL activation, this hip position could be used to facilitate training.

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Currently, evidence is contradictory with regard to the effect of hip position on VMO activation. McConnell[16] and Wheatley and Jahnke[17] have suggested that altering the position of the lower limb does facilitate preferential activation of the VMO. However, several studies[18–20] have not supported these findings. Therefore, whether hip position, specifically external hip rotation, can significantly increase VMO activity is currently under debate. Internal rotation of the hip increases VL activity.[17] Therefore, one could predict that an externally rotated hip would both increase VMO activation and decrease VL activation, thus acutely altering the VMO:VL ratio in a positive direction. Further, training the knee extensors while the hip is externally rotated would be expected to facilitate VMO recruitment, thus improving the VMO:VL ratio. Therefore, the purpose of our study was 2-fold: to determine whether biofeedback training can positively affect the VMO:VL ratio and whether the VMO:VL ratio is differentially affected with training in 3 hip positions.

METHODS

Subjects

Thirty-six females with no known right knee musculoskeletal dysfunction volunteered for this study (age = 20.1 ± 1.2 years, height = 166 ± 8.0 cm, weight = 59 ± 11.5 kg). Before participation, all subjects read a description of the study, signed an informed consent that met the requirements of the university's institutional review board, filled out a short medical questionnaire, and were randomly assigned to 1 of 3 experimental groups.

Design

The experimental design was a 3 (group) × 2 (test) mixed design. The independent variable group was a between-subjects design, with levels being the anatomically neutral hip position (group A), maximal external hip rotation (group B), and maximal internal hip rotation (group C). The independent variable test was a within-subjects factor, with the 2 levels being pretest and posttest. The dependent variable of interest was the VMO:VL ratio as assessed through electromyogram (EMG).

Apparatus

EMG biofeedback was provided by the Norodyn 2000 EMG biofeedback unit (Clinical Resources, Nevada City, CA). The unit provided continual visual feedback. We used 3 sets of Norotrode 2.0 silver-silver chloride surface bipolar electrodes. Interelectrode spacing was 20.0 ± 1 mm. The offset potential was 1.0 mV, and the impedance of the electrodes at 60 Hz was approximately 20 Ω.

One set of electrodes was placed over the greatest bulk of the VMO, and a second set was placed over the greatest bulk of the VL. A third set of electrodes was placed near the 2 active electrode sites to function as the ground. Each site of electrode attachment was marked in ink to ensure consistent electrode placement for each treatment session. Electrode sites were shaved, abraded, and rubbed with alcohol wipes to reduce resistance to electric current.

The EMG unit was set up with 2 channels, an EMG gain of 50 μV, and a medium integration period. The unit recorded muscle activity only from the VMO and the VL. The sweep speed was 1 second per division, with 15 divisions across the screen. Processed EMG feedback signals were provided for every contraction, and average EMG values for each division were displayed.

Procedures

In all cases, the protocols for the current study were designed and strictly carried out based on the literature.[21–24] The protocol spanned 5 consecutive days: the pretest on day 1, training sessions on days 2 through 4, and the posttest on day 5. On the first day, subjects were introduced to the operational procedures used with the EMG biofeedback unit, the pretest was conducted, and a portion of a full training session was completed (3 sets of 5 contractions). All testing procedures and training sessions were executed on the right leg only. Subjects were instructed to exert only about 50% effort (approximately 50% of maximum voluntary contraction) to reduce fatigue. For the pretest, subjects were seated in a comfortable semirecumbent position with the knee in terminal extension. Six 5-second isometric contractions of the knee extensor muscles were performed, with a 25-second rest period between contractions. Two contractions were performed in each of the 3 target hip positions (the anatomically neutral position, maximal external rotation, and maximal internal rotation). The electrical activity of each set of 2 contractions was averaged for each subject, and the average was then used to compute the VMO:VL ratio for each hip position. On day 5, we duplicated the procedures for the pretest as a posttest to reassess the electric activity produced by the VMO and VL.

For each training session, we placed subjects in a semirecumbent position with the knee in terminal extension and the hip in one of the 3 target positions, according to their random assignment. Assignments were made to group A (anatomically neutral hip position), group B (maximal hip external rotation), or group C (maximal hip internal rotation). We made sure that subjects could easily view the biofeedback monitor, since all groups received EMG biofeedback during each training session. Subjects were then instructed to perform submaximal isometric contractions of the right quadriceps muscle and to observe the electrical activity displayed on the computer screen. Each isometric contraction was 10 seconds long, with a 15-second rest period between contractions. Five contractions and 4 rest periods constituted a single set, and 5 sets constituted a training session. All subjects were informed that the EMG biofeedback unit monitored electric activity of the thigh muscles and that the amplitude of the lines drawn by the EMG biofeedback unit represented the amount of effort used during contraction of the thigh muscles (Figure 1). We told

Figure 1. Arrangement of subject and EMG biofeedback equipment.

subjects to concentrate and attempt to increase the amplitude of the line associated with the VMO and to decrease the amplitude of the line corresponding to the VL. No form of encouragement or suggestion of strategy was provided to the subjects.

Statistical Analysis

We used a 3 (group) × 2 (test) analysis of variance with repeated measures on the last factor to analyze the mean VMO:VL ratio data. The electrical activity of each contraction during the pretest and posttest was recorded for each subject. The data analysis was conducted on the contractions performed in the hip position used by the subject in training. Thus, we used only 2 sets of contractions for the analysis. Mean VMO values were divided by mean VL values for both the pretest and the posttest; these data were used in the final analysis.

RESULTS

The mean VMO:VL ratios of myoelectric activity while performing isometric quadriceps contractions for 5 seconds during the pretest were 1.028 for group A, 0.843 for group B, and 0.773 for group C (Table 1). The mean ratios increased during the posttest to 1.423, 1.485, and 1.037 for group A, group B, and group C, respectively (Figure 2).

The main effect for group was not significant ($F_{2,33}$ = 2.19, P = .1278, power = 0.44). We interpret this finding to suggest that the position of the hip during EMG biofeedback training did not affect the VMO:VL ratio. The main effect for tests was significant ($F_{1,33}$ = 38.74, $P < .001$, calculated power > 0.99), reflecting an increase in the VMO:VL ratio from the pretest to the posttest independent of hip position. The group-by-test interaction was not significant ($F_{2,33}$ = 2.03, P = .1471, power = 0.46). Because the power was not high, we generated a computer-simulated model of data similar to that gathered, but with an increased sample size. The results indicated that, with a substantial increase (doubling) in the number of subjects, the data would yield significant main effects and group-by-test interaction. However, the large number of subjects that would be required for statistical significance may bring the clinical significance into question.

DISCUSSION

The goals of our study were to determine whether biofeedback training can positively affect the VMO:VL ratio and whether the VMO:VL ratio is differentially affected with training in 3 different hip positions. All subjects were able to

Table 1. VMO:VL Ratios as Recorded by EMG

		Pretest			Posttest		
Rotation (group)	n	Mean ± SD	Range	SEM	Mean ± SD	Range	SEM
Neutral (A)	12	1.028 ± .358	.560-1.83	.1033	1.423 ± .367	.910-1.96	.1060
External (B)	12	0.843 ± .501	.430-1.12	.1447	1.485 ± .646	.850-2.39	.1864
Internal (C)	12	0.773 ± .347	.270-1.39	.1002	1.037 ± .330	.560-1.70	.0954

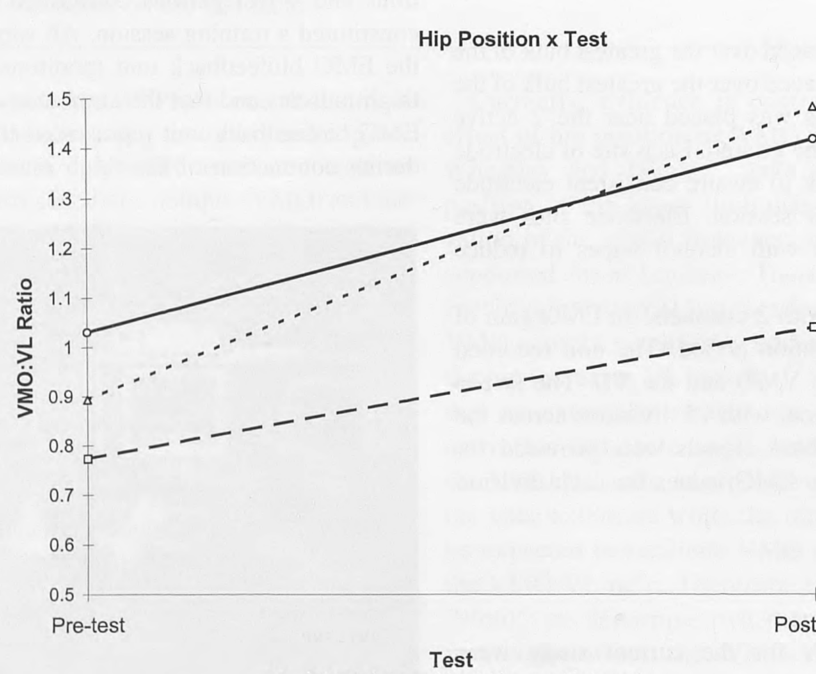

Figure 2. VMO: VL ratios between the pretest and the posttest.

increase their VMO:VL ratio in 5 days regardless of hip position, thus supporting the use of EMG biofeedback. However, hip position did not appear to differentially affect the VMO:VL ratio. Our results support previous research[13,25] that has shown EMG biofeedback to be an effective means to selectively train the VMO in relation to the VL. However, our present study is unique in that the VMO:VL ratio was affected in a 4-day training period. Previous studies of EMG biofeedback to alter the VMO:VL ratio have used a greater number of training sessions.[13,25] Our results suggest that the VMO:VL ratio can be increased by using EMG biofeedback during isometric contractions with the knee in terminal extension, resulting in a significant difference between the pretest and the posttest for all groups after only 4 training sessions. This finding supports previous studies that demonstrated the ability of subjects to learn a novel skill using EMG biofeedback in 5 days.[26–28] These results further support Leroux et al,[29] who examined the relative contribution of the VMO to knee extension. Using electrical stimulation, Leroux et al[29] found that the VMO contributed only 6.31% of the total torque produced during a maximum voluntary isometric knee extensor contraction. Therefore, the VMO is unlikely to respond well to resistive knee extension, regardless of manipulations of hip position or range of motion. Leroux et al[29] further concluded that biofeedback or electrical stimulation can be recommended to facilitate VMO strengthening.

With regard to our study, several points of application and research methodology need to be addressed. As noted, we used apparently healthy subjects to test VMO strengthening through biofeedback, in general. Further, it may be that the lack of significant differences between groups is attributable to a relatively small sample size. However, we determined through computer simulation that the sample size would need to more than double in order to generate statistically significant findings. Such a large number of subjects to potentially reveal statistical significance begs the question of the applicability of the results. That is, increasing the number of subjects may be statistically significant without being clinically significant.

Finally, it could be argued that the lack of a control group made the assessment of learning difficult. Again, the primary purposes of our study were to determine whether biofeedback training can positively affect the VMO:VL ratio and to determine whether the VMO:VL ratio is differentially affected with training in 3 hip positions. Based on an evaluation of pretest versus training day 1, the pretest had no significant effect on the VMO:VL ratio. Therefore, we can presume that a pretest-posttest design adequately answers the question of whether or not biofeedback training can positively affect the VMO:VL ratio. Clearly, no control group is needed to determine whether the 3 leg positions were differentially affected since the comparison was among groups, not between tests (pretest and posttest). This was a first step into future studies that may investigate VMO strengthening through biofeedback using PFPS patients.

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REFERENCES

1. DeHaven KE, Lintner DM. Athletic injuries: comparison by age, sport, and gender. *Am J Sport Med.* 1986;14:218–224.
2. Ficat RP, Hungerford DS. *Disorders of the Patello-Femoral Joint.* Baltimore, MD: Williams & Wilkins; 1977:29–32.
3. Fox TA. Dysplasia of the quadriceps mechanism: hypoplasia of the vastus medialis muscle as related to the hypermobile patella syndrome. *Surg Clin North Am.* 1975;55:199–226.
4. Grabiner MD, Koh TJ, Draganich LF. Neuromechanics of the patellofemoral joint. *Med Sci Sports Exerc.* 1994;26:10–21.
5. Steadman JR. Nonoperative measures for patellofemoral problems. *Am J Sports Med.* 1979;7:374–375.
6. Boucher JP, King MA, Lefebvre R, Pepin A. Quadriceps femoris muscle activity in patellofemoral pain syndrome. *Am J Sports Med.* 1992;20:527–532.
7. Souza DR, Gross MT. Comparison of vastus medialis obliquus:vastus lateralis muscle integrated electromyographic ratios between healthy subjects and patients with patellofemoral pain. *Phys Ther.* 1991;71:310–320.
8. Bose K, Kasnagasuntheram R, Osman M. Vastus medialis oblique: an anatomical and physiologic study. *Orthopedics.* 1980;3:880–883.
9. Lieb FJ, Perry J. Quadriceps function: an anatomical and mechanical study using amputated limbs. *J Bone Joint Surg Am.* 1968;50:1535–1548.
10. Mariani PP, Caruso I. An electromyographic investigation of subluxation of the patella. *J Bone Joint Surg Br.* 1979;61:169–171.
11. Brownstein BA, Lamb RI, Mangine RE. Quadriceps torque and integrated EMG. *J Orthop Sports Phys Ther.* 1985;6:309–314.
12. Insall J. Current concepts review: patellar pain. *J Bone Joint Surg Am.* 1982;64:147–152.
13. LeVeau B, Rogers C. Selective training of the vastus medialis muscle using EMG biofeedback. *Phys Ther.* 1980;60:1410–1415.
14. Levine J. Chondromalacia patellae. *Physician Sportsmed.* 1979;7(8): 41–49.
15. Lieb FJ, Perry J. Quadriceps function: an electromyographic study under isometric conditions. *J Bone Joint Surg Am.* 1971;53:749–758.
16. McConnell J. The management of chondromalacia patellae: a long-term solution. *Austral J Physiother.* 1986;32:215–223.
17. Wheatley MD, Jahnke WD. Electromyographic study of superficial thigh and hip muscles in normal individuals. *Arch Phys Med Rehabil.* 1951;32: 508–515.
18. Cerny K. Vastus medialis oblique/vastus lateralis muscle activity ratios for selected exercises in persons with and without patellofemoral pain syndrome. *Phys Ther.* 1995; 17:672–683.
19. Karst GM, Jewett PD. Electromyographic analysis of exercises proposed for differential activation of medial and lateral quadriceps femoris muscle components. *Phys Ther.* 1993;73:286–299.
20. Wild JJ Jr, Franklin TD, Woods GW. Patellar pain and quadriceps rehabilitation: an EMG study. *Am J Sports Med.* 1982;10:12–15.
21. DeVries, HA. Method for evaluation of muscle fatigue and endurance from electromyographic fatigue curves. *Am J Phys Med.* 1968;47:125–135.
22. Fridlund AJ, Cacioppo JT. Guidelines for human electromyographic research. *Psychophysiology.* 1986;23:567–589.
23. Graham GP. Reliability of electromyographic measurements after surface electrode removal and replacement. *Percept Mot Skills.* 1979;49:215–218.
24. Kramer H, Breuer D, Kuchler G. On the reliability of electromyographic measurements using surface electrodes. *Acta Biol Med Ger.* 1972;29: 381–388.
25. Ingersoll CD, Knight KL. Patellar location changes following EMG biofeedback or progressive resistive exercises. *Med Sci Sports Exerc.* 1991;23:1122–1127.

26. Colborne GR, Olney SJ. Feedback of joint angle and EMG in gait of able-bodied subjects. *Arch Phys Med Rehabil.* 1990;71:478–483.
27. Koga S. Acquisition of self-control of a novel muscular activity with EMG and video feedback. *Percept Mot Skills.* 1989;69:19–26.
28. Sabourin M, Rioux S. Effects of active and passive EMG biofeedback training on performance of motor and cognitive tasks. *Percept Mot Skills.* 1979;49:831–835.
29. Leroux A, Poumarat G, Boucher JP. Investigation of quadriceps femoris function through electrical stimulation. *J Athl Train.* 1997;32:115–118.

COMMENTARY

Ted W. Worrell, EdD, PT, ATC

Associate Editor

I have been asked to comment on the paper, "The Effect of Hip Position and Electromyographic Biofeedback Training on the Vastus Medialis Oblique:Vastus Lateralis Ratio," by Davlin et al. I commend the authors for studying a complex issue with great relevance to athletic training clinical practice. I will address 4 main issues concerning the authors' paper. My comments are intended to be constructive in nature and to advance the level of scholarship published in the *Journal of Athletic Training*.

VMO:VL Ratio as Related to Patellofemoral Pain Syndrome (PFPS)

The authors make the following statements in the introductory paragraph [Editor's note: references apply to the original article]: "This disorder is commonly associated with an imbalance between the vastus medialis oblique (VMO) and the vastus lateralis (VL) muscles. PFPS patients typically exhibit a marked decrease in VMO activity,[4,6,7] decreasing the ability of the VMO to produce medial patellar forces to counteract the lateral forces produced by the VL.[4,8–10] For this reason, reestablishing balance between the VMO and VL is the primary goal of PFPS rehabilitation programs."

The authors cite Grabiner et al,[1] Souza and Gross,[2] and Boucher et al[3] to support "PFPS patients typically exhibit a marked decrease in VMO activity." My interpretation of Grabiner et al[1] is quite different. Grabiner et al[1] argued against selective strengthening, as revealed by the following statement: "However, quantification of in vivo selective strengthening in humans is simply not possible" (p. 17). The more important issue is that of selective recruitment of the VMO compared with the VL, which can be quantified. Grabiner et al[1] argued against such a hypothesis and cited their 1992 paper,[4] in which they demonstrated no selective fatigue of VMO compared with VL in vivo and, therefore, determined that selective VMO recruitment is not likely: "The series of experiments performed in a single laboratory perhaps offer the strongest evidence against selective VMO activation and strengthening within the framework of the limitations associated with the measurement and quantification of muscle activation data" (p. 19).

Souza and Gross[2] used nonnormalized EMG data (an inappropriate use) to demonstrate a significant difference between PFPS and normal subjects. Their conclusions were refuted by Minor:[5] "I believe the methodological limitations of using nonnormalized EMG data is [*sic*] serious enough to question consideration of such data and render conclusions based on these data invalid." Boucher et al[3] reported no significant differences in VMO:VL ratios when comparing the total group of PFPS patients with the asymptomatic group. Only when they reanalyzed their data by comparing the 5 worst patients (by largest Q-angle) with the control group did they report a significant difference. Boucher et al[3] did not adjust the *P* value for this analysis, nor did they report the standard error of measurement (SEM). Therefore, we do not know if the "significant difference" in VMO:VL ratio exceeded the SEM.

In summary, evidence for a relationship between VMO activity and abnormal patellar tracking is lacking. In fact, Grabiner et al[1] cited 9 references reporting no differences in VMO activation level in PFPS and normal subjects. Recent research by Powers et al[6] and Cerny[7] showed no significant difference in VMO:VL ratios in PFPS subjects compared with asymptomatic subjects. These papers, in my opinion, have the best methodologies to answer the question of VMO:VL ratios in PFPS and asymptomatic subjects. In addition, Worrell et al[8] have reported widely varying (0.35 to 11.12) multiple-angle isometric VMO:VL ratios in asymptomatic subjects. I believe the literature, as described in the Table, fails to support a relationship between PFPS and selective VMO inhibition, that is, a decreased VMO:VL ratio.

Use of Asymptomatic Subjects: Lack of External Validity

In order to generalize to the athletic population with PFPS, the authors must study such a population. Moreover, it would be necessary to demonstrate that an increased VMO:VL ratio was associated with decreased symptoms and increased function. This very complex research question would require many subjects and control of confounding variables, such as placebo and natural history effects. If the study findings are not applicable to the patient with PFPS, the value of the study would seem questionable. My point is that the effect of EMG training on normal subjects is of little value to the clinician treating athletes with PFPS.

Reliability

The authors have selectively cited papers to support EMG testing as reliable. However, the literature is replete with reports of low EMG reliability, especially between sessions.[8,12,13] From the 6 pretest repetitions, Davlin et al have the data to report intraclass correlation coefficients and SEMs for the testing situations. These data would allow readers to appreciate the actual variance of the EMG testing, and, indeed,

Table 2. Literature Summary Concerning VMO:VL Ratios in Subjects with Patellofemoral Pain Syndrome (PFPS) and Asymptomatic Subjects (Asymp)

Authors	Subjects	Methods	Dependent Variables	EMG Reliability	Results
Souza and Gross[2] 1991	9 PFPS 7 Asymp	Surface electrodes OKC and CKC exercises Control group and both legs of PFPS subjects (3 groups)	Normalized and nonnormalized VMO:VL ratios	None	NSD VMO:VL ratios using normalized data: PFPS = 1.30 ± .25, Asymp EXT = 1.10 ± .26, Control ratio = 1.10 ± 0.27 SD VMO:VL ratios using nonnormalized data: PFPS = 0.41 ± 0.25, Asymp EXT = 0.40 ± 0.12 Control ratio = 0.57 ± 0.14
Grabiner et al[4] 1992	8 PFPS 15 Asymp	Surface electrodes, OKC exercises at 20%, 50%, and 80% MVIC CKC stepping	Normalized VMO:VL ratios	None	NSD in VMO:VL ratios in PFPS vs Asymp MVICs, SD in CKC in both VMO and VL in PFPS vs Asymp
Boucher et al[3] 1992	18 PFPS, then 5 Asymp vs 5 PFPS > Q-angle	Surface electrodes OKC exercises at 90°, 60°, and 30°	Normalized VMO:VL ratios	None	NSD VMO:VL ratios and angles in PFPS (1.86) vs Asymp (1.96); in 5 PFPS vs 5 Asymp subjects, SD in VMO:VL ratios @ 15° (1.25 vs 2.0)
Väätäinen et al[9] 1995	41 Chondromalacia patellae 31 Asymp	Surface electrodes OKC	Peak torque/body weight IEMG/force Normalized VMO:VL ratios	None	NSD in VMO:VL ratios: chondromalacia patellae = 1.03 ± .23, PFPS = 1.09 ± .33, SD in chondromalacia patellae peak torque/body weight = 1.83 ± .68 vs Asymp = 2.66 ± .51 SD in IEMG/force for all quadriceps in chondromalacia patella < Asymp
Cerny[7] 1995	10 PFPS 21 Asymp	Wire electrodes, CKC and OKC exercises Patellar taping	VMO & VL IEMG, Normalized VMO:VL ratios, pain	ICCs = .81 to .93	NSD in VMO:VL ratios with taping; NSD VMO:VL ratios: PFPS 0.9 to 1.2 vs Asymp 1.0 to 1.3, hip medial rotation ratios > hip lateral rotation in Asymp 94% reduction in pain with taping
Powers et al[6] 1996	26 PFPS 19 Asymp	Wire electrodes 6 CKC activities	EMG onset and cessation Normalized EMG intensity	None	NSD in EMG timing PFPS = decreased EMG intensity in 4/6 activities, no difference in VMO:VL ratios
Miller et al[10] 1997	6 PFPS 15 Asymp	Surface electrodes 4 OKC exercises	100% normalized MVIC VMO:VL ratios	ICC = .99 SEM = .02 to .05	SD in VMO:VL ratios during 4/5 CKC activities PFPS = <1.0, Asymp = 2.2 to 2.7 NSD in ratios with leg rotation in PFPS activities
Laprade et al[11] 1998	8 PFPS 19 Asymp	Surface electrodes 5 OKC exercises	50% normalized MVIC VMO:VL ratios	None	NSD in VMO:VL ratios, PFPS = .39 to 1.42, Asymp = .57 to 1.48 Medial tibial rotation and knee extension VMO:VL ratios > other MR, hip adduction, and extension exercise VMO:VL ratios

* OKC, open kinetic chain; CKC, closed kinetic chain; NSD, no significant difference; SD, significant difference; MVIC, maximal voluntary isometric contraction; SEM, standard error of measurement; EXT, extremity; MR, medial rotation.

all EMG studies should include reports of reliability of measurement.

Power

Power is influenced by factors in addition to the number of subjects: (1) the a priori anticipated difference between groups, (2) the actual or observed difference between groups, (3) the within-group variable, and (4) the number of subjects. The large within-subject variance of VMO:VL ratios and the variability of the EMG both influence the lower power of the authors' study.

In conclusion, Davlin et al have attempted to provide insights into the complex problems of PFPS using asymptomatic subjects. The use of EMG to compare VMO with VL is replete in the literature with oversimplification and overgeneralization, which has led to misleading and contradictory results. My recommendations for future research include careful and thorough review and interpretation of the related literature, testing of subjects experiencing patellofemoral pain, careful standardization of EMG test procedures to include analysis and reporting of measurement reliability, and appropriate statistical interpretation (to include power analysis) of the data. I hope my comments will help future authors investigating this topic.

REFERENCES

1. Grabiner MD, Koh TJ, Draganich LF. Neuromechanics of the patellofemoral joint. *Med Sci Sports Exerc.* 1994;26:10–24.
2. Souza DR, Gross MT. Comparison of vastus medialis obliquus:vastus lateralis muscle integrated electromyographic ratios between healthy subjects and patients with patellofemoral pain. *Phys Ther.* 1991;71:310–320.
3. Boucher JP, King MA, Lefebvre R, Pepin A. Quadriceps femoris muscle activity in patellofemoral pain syndrome. *Am J Sports Med.* 1992;20:527–532.
4. Grabiner MD, Koh TJ, Haefen LV. Decreased excitation of vastus medialis oblique and vastus lateralis during static and dynamic knee extension. *Eur J Exp Musculoskel Res.* 1992;1:33–39.
5. Minor SD. Commentary. *Phys Ther.* 1991;71:317–318.
6. Powers CM, Landel R, Perry J. Timing and intensity of vastus muscle activity during functional activities in subjects with and without patellofemoral pain. *Phys Ther.* 1996;76:946–955.
7. Cerny K. Vastus medialis oblique/vastus lateralis muscle activity ratios for selected exercises in persons with and without patellofemoral pain syndrome. *Phys Ther.* 1995;75:672–683.
8. Worrell TW, Connelly S, Hilvert J. VMO:VL ratios and force comparisons at four angles of knee flexion. *J Sport Rehabil.* 1995;4:264–272.
9. Väättäinen U, Airaksinen H, Jaroma H, Kiviranta I. Decreased torque and electromyographic activity in the extensor thigh muscles in chondromalacia patellae. *Int J Sports Med.* 1995;16:45–50.
10. Miller JP, Sedory D, Croce RV. Leg rotation and vastus medialis oblique/vastus lateralis electromyographic activity ratio during closed kinetic chain exercises prescribed for patellofemoral pain. *J Athl Train.* 1997;32:216–220.
11. Laprade J, Culham E, Brouwer B. Comparison of five isometric exercises in the recruitment of the vastus medialis oblique in persons with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 1998;27:197–204.
12. Yang JF, Winter DA. Electromyography reliability in maximal and submaximal isometric contractions. *Arch Phys Med Rehabil.* 1983;64:417–420.
13. Solomonow M, Baratta R, Shoji H, D'Ambrosia R. The EMG-force relationships of skeletal muscle: dependence on contraction rate, and motor units control strategy. *Electromyogr Clin Neurophysiol.* 1990;30:141–152.

AUTHORS' RESPONSE

Christina D. Davlin, MS, ATC; William R. Holcomb, PhD, ATC, CSCS; Mark A. Guadagnoli, PhD

Recently, we were asked to take part in a new endeavor for the *Journal of Athletic Training*. The Editor-in-Chief wanted to publicize the dialogue between 1 reviewer, Dr. Ted Worrell, and us with regard to a manuscript we had submitted for publication. Below is the last interchange of this dialogue. We wish to compliment the *Journal of Athletic Training* on its innovative thought regarding our manuscript and the comments of Dr. Worrell. We believe that such a public interaction may very well serve the purpose of stimulating more professional interactions of this type. Further, we believe that this type of interaction has a strong potential to forward research in the field of athletic training. Additionally, we would like to thank Dr. Worrell for taking the time to prepare his commentary for publication and an anonymous reviewer who made several positive and germane comments on earlier reviews of the manuscript.

One of Dr. Worrell's valid points was with regard to the lack of evidence supporting the relationship between VMO activity and PFPS. The relationship between PFPS and a decreased VMO:VL ratio is still under debate. However, based on the function of the VMO and VL as patellar stabilizers, selective VMO strengthening is commonly recommended for the rehabilitation of patients with anterior knee pain.[1–12] Therefore, the purpose of our study was to investigate a possible means of selectively strengthening the VMO. It was not our intention to establish proof of the relationship between the VMO:VL ratio and PFPS. Rather, we stated that our intention was to investigate whether the VMO:VL ratio could be trained through practice.

Dr. Worrell's second point was with regard to a potential lack of external validity. We agree that, if one attempted to directly apply the current findings to a clinical population, this could be a threat to external validity. However, we did not apply our results to a clinical population. In fact, we were careful to state, ". . . the purpose of our study was 2-fold: to determine whether biofeedback training can positively affect the VMO:VL ratio and whether the VMO:VL ratio is differentially affected with training in 3 hip positions." The purpose of the study was not to investigate PFPS or any other pathology. Clearly, direct application of these results to a clinical population would be at the clinician's discretion rather than ours. In fact, in the final paragraphs of the paper, we stated, "With regard to our study, several points of application and research methodology need to be addressed. As noted, we used apparently healthy subjects to test VMO strengthening through biofeedback, in general. . . . This was a first step into future studies that may investigate VMO strengthening through biofeedback using PFPS patients." Therefore, we interpreted our results to suggest that, with healthy subjects, biofeedback training can positively impact the VMO:VL ratio and that this training is not differentially affected by hip position during training. A logical extension of our study is to focus on the impact of biofeedback training on the VMO:VL ratio of a clinical population (eg, PFPS).

With regard to the question of the variability of EMG data confounding the results, we submit several previous publications in answer. For example, our study followed the suggestions of Fridlund and Cacioppo,[13] who proposed guidelines for the collection, analysis, and description of EMG data. The guidelines cover technologic issues in EMG recording, social aspects of EMG experimentation, and limits to inferences. A second example is that of Graham,[14] who used 8 male subjects performing an isometric exercise with the left triceps brachii muscle. The loads were equivalent to 30%, 40%, and 50% of their maximum voluntary contractile strength. Graham[14] used surface electrodes and recorded the integrated action potentials electromyographically as the muscle contracted. Each of the subjects was tested 3 different times, with a range of 2 to 16 days between testing sessions. The test-retest correlations for the three testing periods ranged from 0.87 to 0.99. These results applied to all loads and under conditions of muscle rest and fatigue. Graham[14] employed strict standardization, including marking electrode placement with indelible ink. As noted in the manuscript, we also followed this protocol. For example, the same researcher applied the electrodes on each patient for every trial, and subjects were marked with indelible ink. DeVries[15] allowed a 1-week to 3-week interval between tests involving EMG fatigue curves at 40% of measured MVC. A correlation of 0.83 was obtained using unipolar surface electrodes on the belly of the biceps brachii of 13 subjects. Kramer et al[16] allowed 1 week between tests for 14 subjects performing isometric contractions. Reliability coefficients of 0.77 with unipolar and 0.79 with bipolar electrodes were obtained at 60% MVC. Considering the work noted above and the fact that we paid great heed to these studies and practiced a strictly consistent data collection protocol, we are hard-pressed to understand why our results would be less reliable than those cited.

Dr. Worrell's final point is with regard to the discussion of power. Several variables can affect power. In our study, a potential source of such unexplained variability is a low number of subjects (relative to variability). As such, we generated a computer-simulated model of data similar to that gathered. The models differed in the number of subjects used (ie, increasing sample size while maintaining relative data points). The results of these simulations led us to conclude that we would need a 2-fold increase in subjects to yield statistically different results. We felt that this finding brought up an important question regarding the clinical application of the findings. Specifically, in the manuscript we stated that ". . . it may be that the lack of significant differences between groups is attributable to a relatively small sample size. However, we determined through computer simulation that the sample size would need to more than double in order to generate statistically significant findings. Such a large number of subjects to potentially reveal statistical significance begs the question of the applicability of the results. That is, increasing the number of subjects may be statistically significant without being clinically significant." Again, the point of power should be addressed in any manuscript.

The comments and suggestions made by Dr. Worrell and an anonymous reviewer were very helpful in preparing this version of the article. We would like to thank Dr. Worrell, the second reviewer, and the *Journal of Athletic Training* again for their work on this article and for this opportunity. We encourage other investigators to pursue the research questions and issues raised in the current article and the following commentaries. It is our desire that this dialogue will inspire further research and discussion that will ultimately advance the scientific basis of our profession.

REFERENCES

1. Bohannon R. Effects of electrical stimulation to the vastus medialis muscle in a patient with chronically dislocating patellae: a case report. *Phys Ther*. 1983;36:1445–1447.
2. Hanten WP, Schulthies SS. Exercise on electromyographic activity of the vastus medialis oblique and vastus lateralis muscles. *Phys Ther*. 1990;70: 561–565.
3. Ingersoll CD, Knight KL. Patellar location changes following EMG biofeedback or progressive resistive exercises. *Med Sci Sports Exerc*. 1991;23:1122–1127.
4. LeVeau BF, Rogers C. Selective training of the vastus medialis muscle using EMG biofeedback. *Phys Ther*. 1980;60:1410–1415.
5. McConnell J. The management of chondromalacia patellae: a long-term solution. *Austral J Physiother*. 1986;32:215–222.
6. Reynolds L, Levin TA, Medeiros JM, Adler NS, Hallum A. EMG activity of the vastus medialis oblique and vastus lateralis in their role in patellar alignment. *Am J Phys Med*. 1993;62:61–70.
7. Ruffin MT 5th, Kiningham RB. Anterior knee pain: the challenge of patellofemoral syndrome. *Am Fam Physician*. 1993;47:185–194.
8. Sczepanski T, Gross P, Duncan P, Chandler J. Effect of contraction type, angular velocity and arc of motion on VMO:VL EMG ratio. *J Orthop Sports Phys Ther*. 1991;14:256–262.
9. Shelton GL, Thigpen LK. Rehabilitation of patellofemoral dysfunction: a review of literature. *J Orthop Sports Phys Ther*. 1991;14:243–249.
10. Westfall DC, Worrell TW. Anterior knee pain syndrome: role of the vastus medialis oblique. *J Sport Rehabil*. 1992;1:317–325.
11. Wise H, Fiebert I, Kates J. EMG biofeedback as treatment for patellofemoral pain syndrome. *J Orthop Sports Phys Ther*. 1984;6:95–103.
12. Woodall W, Welsh J. A biomechanical basis for rehabilitation programs involving the patellofemoral joint. *J Orthop Sports Phys Ther*. 1990;11: 535–542.
13. Fridlund AJ, Cacioppo JT. Guidelines for human electromyographic research. *Psychophysiology*. 1986;23:567–589.
14. Graham GP. Reliability of electromyographic measurements after surface electrode removal and replacement. *Percept Mot Skills*. 1979;49:215–218.
15. DeVries HA. Method for evaluation of muscle fatigue and endurance from electromyographic fatigue curves. *Am J Phys Med*. 1968;47:125–134.
16. Kramer H, Brauer D, Kuchler G. On the reliability of electromyographic measurements using surface electrodes. *Acta Biol Med Ger*. 1972;29: 381–388.

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Prevention of Tinea Corporis in Collegiate Wrestlers

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Objective: To examine the role of a comprehensive skin disease prevention protocol in conjunction with the use of a barrier cream to prevent tinea corporis (ringworm) in collegiate wrestlers.

Design and Setting: We studied a college wrestling team for 16 weeks during 1 season. During the first 8 weeks, no preventive measures were taken. For the remaining 8 weeks, wrestlers were randomized into 2 groups and used either a barrier or a placebo.

Subjects: Twenty-two male college wrestlers with a mean age of 20.4 years (range, 18.1 to 23.2), a mean weight of 68.4 kg (range, 55.8 to 130.2), and a mean height of 177.8 cm (range, 168.7 to 186.9).

Measurements: We performed skin checks daily. All new or exacerbated lesions were clinically diagnosed by the same team physician and recorded.

Results: Cases of tinea corporis declined from 10 diagnosed before initiation of the protocol to 1 after the protocol was initiated. One athlete in the placebo group was found to have tinea corporis versus none in the barrier cream group.

Conclusions: Strict adherence to the prevention protocol for skin infections significantly decreased the number of cases of tinea corporis. The use of the barrier cream in conjunction with the prevention protocol did not result in any further statistical reduction in the number of wrestlers who contracted tinea corporis.

Key Words: ringworm, barrier cream, skin infections, wrestling, prevention

Tinea corporis, or ringworm, hinders wrestlers by forcing them to cease wrestling practice while contagious, and it may disqualify them from competition.[1] Diagnosing and treating ringworm can be costly to the athlete, the wrestling program, the school or institution, and the responsible insurance company. Prevention of ringworm in wrestling would be of great benefit to athletes, coaches, and supporting medical personnel, decreasing the time the wrestler is withheld from practice and competitions and reducing the costs of diagnosis and treatment.

In an attempt to find an effective preventive regimen, our approach was to use a comprehensive skin disease prevention protocol in combination with a barrier cream. The barrier cream was Kenshield (Kennedy Industries, Maple Glen, PA), a white, nongreasy foam. It consists of polydimethylsiloxane, isopropyl myristate, glycerine, and water. No adverse reactions to this product have been reported in the literature. It must be applied to dry skin and should be reapplied between matches at tournaments or during prolonged wrestling events. The manufacturer claims that Kenshield will protect the athlete for up to 4 hours (the typical wrestling practice is between 2 and 3 hours) by forming a semipermeable barrier on the wrestler's skin.

The purpose of this study was to test our prevention protocol for skin infections used in conjunction with Kenshield barrier cream to prevent ringworm in collegiate wrestlers. Our hypotheses were that, during a collegiate wrestling season, (1) the implementation of a protocol for skin infection prevention would reduce the number of ringworm infections, and (2) the additional use of Kenshield with the protocol would further reduce the number of ringworm infections in comparison with the use of a placebo.

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METHODS

After obtaining appropriate institutional approval, we studied 22 collegiate Division I wrestlers (the whole team) with a mean age of 20.4 years (range, 18.1 to 23.2 years). The mean weight was 68.4 kg (range, 55.8 to 130.2), and mean height was 177.8 cm (range, 168.7 to 186.9) at the beginning of this study. We obtained informed consent by having the head athletic trainer (J.W.H.) explain the study to the entire team and answer questions at a team meeting. Each team member then signed a form acknowledging his understanding and granting consent.

In the first 8 weeks of this 16-week study, no special precautions were taken to prevent skin diseases. Wrestlers were allowed to decide about skin hygiene themselves. This period of time served as a baseline for us to determine the number of ringworm cases to expect during a typical 8 weeks of college wrestling. No wrestler began the study with any skin lesions.

During the second 8 weeks of the study, our skin disease prevention protocol was initiated (Table). All wrestlers who had had a ringworm infection during the first 8 weeks (5 of 11 in each group) had been successfully treated; thus, all wrestlers were clear of ringworm entering this phase of the study. The 22 wrestlers were randomly selected into 2 groups of 11. Group 1 had Kenshield barrier cream, and group 2 had a placebo cream applied before each practice or match. Neither the wrestlers nor the investigators knew which cream was applied to which group until the end of the study. Strict adherence to the skin disease prevention protocol was mandatory for wrestlers in both groups, and any wrestler who did not adhere to this protocol was excluded from the study. Two athletes (1 from each group) were excluded for wrestling without the use of barrier cream and were not included in the statistical analysis.

The same certified athletic trainer (J.W.H.) performed skin checks daily. All skin lesions and their characteristics were charted on a topographic anatomy chart designated for each individual. Athletes with lesions were then referred for definitive diagnosis to the same team physician, who had 20 years' experience with wrestlers and their skin diseases. Diagnoses were made clinically, ie, by the characteristic appearance of the lesions, not microscopically. A medical report accompanied the athlete to the doctor's office and was used to record the diagnosis.

The application of Kenshield (or placebo cream) to the athlete was observed and assisted by either a certified athletic trainer or 1 of 2 student athletic trainers who had been instructed in the proper application technique. The athletic trainer logged each application. Cream covered every exposed area of the skin, including the scalp, hairline, face, ears, neck, back, arms, and legs. The cream was not applied to athletes withheld from practice due to injury or illness, nor was it applied for those practices consisting only of running or weightlifting. The proper application procedure cannot be stressed enough because, without complete coverage, a barrier will not be constructed.

We analyzed the data in 2 ways. First, we compared the number of cases of ringworm in the first 8 weeks of the study with the number of cases of ringworm in the second 8 weeks of the study. Statistical analysis was performed using McNemar's test and StatXact software (version 3.02; Cytel Software Corporation, Cambridge, MA). Second, we compared cases of ringworm in group 1 versus cases of ringworm in group 2. Statistical analysis was performed using Fisher's exact test. Because of the sparse cell counts, the exact hypergeometric distribution of the test statistic was used to determine significance. We considered $P < .05$ to be significant.

RESULTS

Cases of ringworm declined from 10 (2 head, 4 shoulder, 2 thigh, 1 leg, and 1 back) diagnosed before the protocol was instituted to 1 case (shoulder) after the protocol was initiated. The 2-sided P value was 0.0117, indicating a significant reduction in ringworm incidence. All infected wrestlers were successfully treated with Lamisil (Novartis, Summit, NJ), a topical antifungal cream. No wrestler had a recurrence. Introduction of and strict adherence to the prevention protocol for skin infections thus significantly decreased the number of cases of ringworm.

No adverse reaction to either the placebo or the Kenshield cream was noted in any wrestler during the study period. The only case of ringworm noted after the introduction of the skin disease prevention protocol occurred in a wrestler in the placebo group who had not previously had ringworm. The difference in ringworm incidence between groups 1 and 2 was not statistically significant ($P = 1.00$).

DISCUSSION

Tinea corporis is a superficial fungal infection of the skin of the body that is most prevalent in hot, humid environments. Any member of the microsporum, trichophyton, or epidermophyton dermatophyte families can cause tinea corporis.[2] These fungi can survive for a prolonged period of time in a warm, dark, and humid environment.[3] The incubation period lasts from 2 to 7 days before clinical infection becomes apparent. The organism invades and is nourished by the keratin layer of the skin and the hair follicles.[4]

Inflammatory dermatitis accompanies the infection and causes red, raised borders.[4] Classic ringworm is characterized by 1 or more sharply circumscribed, annular, slightly erythematous, dry, scaly patches with elevated borders and progressive central clearing.[2] The athlete's complaints can range from minimal irritation to severe itching with extensive excoriations and secondary bacterial infection.[3] The condition is not difficult to contract if occlusion, irritation, maceration, or minor abrasions are present. The fungus can be spread through sweat,

Prevention Protocol for Skin Infections

Clean and dry mats at least once daily. We use Kenmat (Kennedy Industries, Maple Glen, PA) mat disinfectant made especially for this purpose. The wrestling room is well ventilated to help dry the mat and reduce the humidity.
Wash and dry workout gear *every* day, after *every* workout.
Shower after *every* workout and after *every* event with an antibacterial soap.
Do not leave wet towels or gear in lockers overnight.
Athletic trainers should examine wrestlers for skin lesions.
All athletes with skin infections or lesions are referred to a physician for diagnosis and treatment.
Infected wrestlers are excluded from practice until lesions are no longer infectious.
Ringworm is considered noninfectious and can be covered by a nonpermeable dressing after 48 to 72 hours of treatment if lesion is "dry" or no longer scaly.

direct body-to-body contact, or contact with contaminated mats, clothes, or furniture. The natural course of tinea corporis ends with spontaneous remission, but reinfection and exacerbations are common.

Treatment of uncomplicated ringworm can be effectively accomplished with the use of topical preparations, including tolnaftate, undecylenic acid, haloprogin, triclosan, and the imidazoles.[3] These agents can be used in cream, lotion, solution, or spray forms. Examples of over-the-counter agents include Tinactin solution (Schering Plough, Madison, NJ), Micatin spray (McNeil Consumer Products, Fort Washington, PA), and several generic antifungal creams. An extensive number of topical preparations are available by prescription. These medications should be used for no less than 4 to 6 weeks. In most cases, these agents clear the infection. In cases of severe or extensive infections in which topical treatments fail, oral antifungal agents such as fluconazole or griseofulvin are used[2,5,6] for 6 weeks. Although these oral antifungals have high success rates, they can have toxic effects on the kidneys and liver and should be used with appropriate caution.[2]

Tinea corporis is a threat to wrestlers because of the constant skin-to-skin contact and minor abrasions that are common to the sport. Skin-to-skin contact between infected wrestlers is the main way ringworm is transmitted.[7] Ringworm can sweep through a team in a matter of days unless wrestlers are monitored and treated effectively. Ringworm hinders the wrestler by forcing him to cease contact activities during practice and may disqualify him from competition.[1] NCAA and high school rules dictate that medical personnel disqualify those with contagious skin infections from competing in championships, tournaments, and other competitions.

Preventive measures are of primary importance and require the cooperation of each wrestler and coach. Protocols for prevention have included some combination of the following: washing of wrestling mats before and after each practice and competition; showers before and after each practice; clean clothing issued before each practice; and exclusion of wrestlers with infections.[1,7,8] We found no current research advocating the use of a barrier cream such as Kenshield or a more extensive skin disease prevention protocol.

The cost of treating ringworm should also be considered. Treatment can become cost prohibitive to the athlete, the wrestling program, the school or institution, and the responsible insurance company if the number of cases on a team is large. The costs of topical or oral medications, as well as the physicians' fees, are the principal expenditures. A typical office visit to a dermatologist costs about $100. A 6-week treatment course of Lamisil cream costs $57.45, making the approximate cost of treating 1 case of ringworm about $160. Each can of Kenshield costs about $12.50, and each wrestler requires about 1.5 cans per season. So, a team with 20 wrestlers on the roster could be treated for an entire season for about $300, or less than the cost of treating 2 cases of ringworm.

We faced 4 main obstacles concerning the methods in this study. First, hygiene and behavior could not be controlled or monitored when wrestlers were at home or away from the wrestling facilities. Two wrestlers (1 from each study group) had contact with their former high school teams over winter break and wrestled unprotected and without adherence to the prevention protocol for skin infections. These wrestlers were excluded from the study. Second, showers were not taken before the application of Kenshield, to rid the body of potentially infectious microorganisms, due to time constraints. Third, the diagnoses were made clinically, not microscopically. Fourth, the study groups were small enough that a potential difference in ringworm incidence in placebo versus Kenshield may not have been detected.

We suggest that further, more extensive research be conducted on the use of prophylactic barrier creams in the prevention of ringworm in wrestlers. Longer study duration, a larger study population, and microscopic diagnosis by a dermatologist may provide more definitive information.

CONCLUSIONS

A comprehensive skin disease prevention protocol achieved a statistically significant 90% reduction in the number of cases of tinea corporis on a college wrestling team. In the half of the team that also received application of Kenshield barrier cream, no wrestlers developed ringworm. This result was not statistically significant, and thus we could not demonstrate that Kenshield adds a preventive effect above that offered by a thorough skin disease prevention protocol. Further study is warranted to determine whether Kenshield can act as an adjunct in preventing ringworm.

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REFERENCES

1. Snook GA. How I manage skin problems in wrestling. *Physician Sportsmed.* 1984:12(3):97–98.
2. Cohn MS. Superficial fungal infections: topical and oral treatments of common types. *Postgrad Med.* 1992;91:239–252.
3. Tschen E. Clinical aspects of superficial fungal infections. *Dermatol Clin.* 1984;2:9–12.
4. Bergfeld W. The diagnoses and treatment of dermatologic problems in athletes. In: Schneider RC, Kennedy JC, Plant, ML, eds. *Sports Injuries: Mechanisms, Prevention, and Treatment.* London, UK: Williams & Wilkins; 1985:73–75.
5. Montero-Gei F, Perera A. Therapy with fluconazole for tinea corporis, tinea cruris, and tinea pedis. *Clin Infect Dis.* 1992;14(suppl):77–81.
6. Bellar M, Gessner BD. An outbreak of tinea corporis gladiatorum on a high school wrestling team. *J Am Acad Dermatol.* 1994;31:197–201.
7. Harvey J, Magsamen B, Strauss RH. Medical problems of wrestlers. *Physician Sportsmed.* 1987;15(1):136–148.
8. Nelson M. Stopping the spread of herpes simplex: a focus on wrestlers. *Physician Sportsmed.* 1992;20(10):116–127.

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An Electromyographic Comparison of 4 Closed Chain Exercises

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Objective: Closed chain exercises are used in the clinical setting to safely strengthen the muscles about the knee. We compared the EMG activity of 3 muscles (vastus lateralis, vastus medialis, and biceps femoris) during 4 closed chain exercises (unilateral one-quarter squat, lateral step-up, FlexCord front pull, and FlexCord back pull) to determine which exercise produced the most muscle activity.

Design and Setting: We used a 4 × 3 × 2 factorial design with repeated measures on exercise, muscle, and movement (knee flexion and extension). Muscle and movement were the control variables for post hoc comparisons. Data were collected in a sports injury research laboratory.

Subjects: Thirty-eight healthy, active female college students aged 21.97 ± 2.8 years, with height 166.9 ± 6.3 cm and weight 61.9 ± 8.5 kg. Subjects had no history of lower extremity pathology that resulted in surgery and no lower extremity pathology within the last year.

Measurements: We placed surface electrodes on the vastus lateralis, vastus medialis, and biceps femoris muscles. Synchronized with a metronome, subjects performed 3 repetitions of 4 exercises between 5° and 30° of knee flexion. Electromyographic measurements were taken from the middle third of the flexion and extension phase of each repetition.

Results: The FlexCord front pull and back pull produced higher levels of biceps femoris activity than the quarter squat and step-up. The FlexCord front pull also produced a higher level of vastus medialis activity during knee extension than the quarter squat, lateral step-up, or FlexCord back pull.

Conclusions: The high levels of biceps femoris activity during the FlexCord exercises indicate that a greater cocontraction exists. With a greater cocontraction, the FlexCord exercises could be safely used during ACL rehabilitation. The high levels of vastus medialis activity during the FlexCord front pull suggest that it may be a beneficial exercise for patellofemoral rehabilitation.

Key Words: knee rehabilitation, quadriceps, hamstrings, quarter squat, step-up, FlexCord

Anterior cruciate ligament (ACL) rehabilitation focuses on increases in range of motion, early weightbearing, and increases in functional strength.[1] This process is challenging because it is difficult to provide traditional exercises that increase strength without endangering the ACL graft. Furthermore, the process is made even more difficult when the athlete's range of motion is limited.

Several strengthening techniques have been studied for ACL rehabilitation.[2–9] Most authors[1,10–14] recommend closed kinetic chain exercises because they reduce shear forces on the ACL graft[3,4,7,15–17] and are more functional than other strengthening exercises.[16] Many closed kinetic chain exercises have been studied to determine their effectiveness during ACL rehabilitation, but no studies have compared muscle activity of closed chain exercises while limiting knee range of motion.

The purpose of our study was to determine which of 4 closed chain exercises (unilateral one-quarter squat, lateral step-up, FlexCord [Functional PT Products, Heber City, UT] front pull, or FlexCord back pull) produces the greatest amount of muscle activity in each of 3 muscles (vastus medialis, vastus lateralis, and biceps femoris) about the knee within approximately 5° to 30° of knee flexion and extension.

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METHODS

Subjects

Volunteers were 38 healthy, physically active female college students (age = 21.9 ± 2.8 years, ht = 166.9 ± 6.3 cm, wt = 61.9 ± 8.5 kg) who had experienced no lower extremity pathology resulting in surgery and no lower extremity pathology in the last year. Subjects gave informed consent to participate in this experiment, which was approved by the Indiana State University Health and Human Performance Human Subjects Committee before testing.

Orientation

We met with all volunteers for 30 minutes 1 to 3 days before testing to explain the testing protocol, determine the dominant leg, and practice the exercises. A general explanation of electromyography and the electrode placement was given. Volunteers demonstrated leg dominance by jumping off each leg and reaching as high as possible to measured points on the wall. The higher of the jumps determined the dominant leg. Proper exercise technique was then demonstrated for each exercise. Volunteers practiced each of the exercises to demonstrate their ability to perform them correctly and in synchronization with the metronome. After the orientation, subjects were assigned to a treatment order using a balanced latin square.

Electromyography

Integrated electromyography (I-EMG) activity of the vastus medialis, vastus lateralis, and biceps femoris was measured using BIOPAC EL503 Ag-AgCl 10-mm surface adhesive/disposable electrodes with the BIOPAC electromyography system (BIOPAC, Goleta, CA). Data were collected with a 4-channel remote amplifier/transmitter telemetry EMG unit (BIOPAC TEL100M) and analyzed with Acknowledge III version 3.0.1 software (BIOPAC). The EMG parameters were as follows: band width = direct current to 30 Hz or 500 Hz, input impedance = 2 MΩ (differential), maximum absolute input voltage between V_{in+} and V_{in-} = 50 mV, sampling rate = 500 Hz, and common mode rejection ratio = 110 dB min (50/60 Hz). The electrodes were connected to the TEL100M with a 1-m lead (BIOPAC SS2).

We placed the EMG electrodes 3.2 cm apart along the line of each muscle's fibers and equidistant from a marked point on the dominant leg. This central point for the vastus medialis was 20% of the distance from the medial joint line to the anterior superior iliac spine.[18] The central point for the vastus lateralis was 25% of the distance from the lateral joint line to the anterior superior iliac spine.[18] The central point for the biceps femoris was 50% of the distance from the ischial tuberosity to the head of the fibula.[18] We shaved an area of 3 cm^2 around each of the electrode placement marks, then debrided the area with an abrasive pad and cleansed with isopropyl alcohol to improve conductivity. We placed the electrodes on the prepared areas. One grounded electrode site was prepared on the proximal fibular head in the same manner as each of the other placements.

Exercises

In each case, the leg doing the work or the affected leg is described as the dominant leg, since the dominant leg was used as the test leg and the subjects had no lower extremity pathology. The nondominant leg is the unaffected or nontest leg.

Unilateral One-Quarter Squat

The subject performed this exercise with the dominant knee and hip flexed and the nondominant knee and hip extended. The subject's trunk and head stayed in an upright, vertical position. The subject touched, but did not hold on to, a handle to help remain upright and balanced. The subject then performed the squat to approximately 30° of flexion in 1 complete motion. To maintain timing between exercises, the subject began the squat from an upright position on 1 tick of the metronome (model S006P; Qwik Time, Woodburn, IN), began upward motion from the squatted position on the next tick, and returned to the upright position by the third tick.

Lateral Step-Up

The subject performed this exercise with the nondominant foot hanging off the edge of a 10-cm step, the dominant or affected foot on the inner part of the step, and the trunk and head remaining in an upright, vertical position. The subject then lowered her nondominant foot to the floor on the first tick of the metronome. While the trunk and head remained upright, she touched the nondominant foot to the floor (approximately 30° of knee flexion) on the second tick of the metronome and returned to the starting position by extending the knee on the third tick of the metronome.

FlexCord Front Pull

The elastic tubing (FlexCord) was 188.82 cm (6 feet) in length with soft handles on each end. The tubing was the medium tension (blue) cord. The FlexCord was placed on the nondominant foot and ankle of each subject. The foot harness maintained the position of the tubing on the foot and ankle at all times. The subject walked from the wall attachment of the tubing to a marked point on the floor 3.4 meters away. She stood with the dominant knee and hip extended and the nondominant leg flexed at the knee and hip against the resistance of the FlexCord, starting from this position on the first tick of the metronome.

After the first tick, the subject flexed the dominant knee to approximately 30° as the tubing pulled the nondominant leg back to another marked point on the floor. The subject touched this point without transferring weight to the nondominant leg on the second tick of the metronome. In this second position, the nondominant leg was extended at the knee and hip with the weight resting primarily on the affected leg. Next, the subject flexed the nondominant hip and knee, pulling the tubing forward to a marked point 15 cm above the floor by the third tick of the metronome. The dominant knee extended as the nondominant foot reached this position (Figure 1).

FlexCord Back Pull

The FlexCord was placed on the nondominant foot and ankle of each subject. The foot harness maintained the position of the tubing on the foot and ankle at all times. The subject walked from the wall attachment of the tubing to a marked point on the floor 2.6 meters away. The subject turned around 180° and faced the tubing attachment. At this point, she was standing upright with both feet together at the marked spot.

Figure 1. FlexCord front-pull starting position (left) and ending position (right).

The elastic tubing pulled the nondominant leg forward, flexing it at the hip and the knee, and the subject touched her toes to a point 15 cm above the floor. The subject maintained the weight over her dominant leg, beginning from this position on the tick of the metronome.

The subject pulled the tubing back to a point marked on the floor while flexing the dominant knee. She touched the nondominant foot on the second tick of the metronome. At this point, the nondominant leg was extended at the hip and knee while the body weight was maintained over the dominant leg (Figure 2). The subject then returned the nondominant leg to its flexed starting position by the third tick of the metronome, extending the dominant knee and hip during this motion.

Testing

Each subject performed 3 repetitions of each exercise with a 3-minute rest between exercises. The data were not normalized, but the electrodes remained in place throughout the exercise sessions. Therefore, I-EMG activity was compared within muscles across the 4 exercises. The rate and depth for each exercise were synchronized using a metronome set at 60 beats per minute. Each exercise was performed so that knee flexion, hip flexion, and dorsiflexion were performed during the first second, whereas knee extension, hip extension, and plantar flexion were performed during the next second.

Figure 2. FlexCord back-pull starting position (right) and ending position (left).

Each subject started with the dominant leg extended. After a 3-second countdown, the subject began the exercise on the command "start." The EMG was also initiated on the "start" command. The EMG signal was recorded for 2 seconds, terminating with the end of the exercise repetition. An area of 1/3 of a second (0.3360 to 0.6720) was highlighted within the first second and again within the next second (1.3360 to 1.6720). The time intervals were chosen to analyze the center of each contraction and exclude some variation of exercise start time between the subject and experimenter. Furthermore, a mean measurement of the 3 trials was used in the analysis to lessen variability between subjects. The raw EMG data were smoothed by an 8-point moving average, rectified, and integrated.

Statistical Analysis

We used an analysis of variance with repeated measures on exercise, movement of the knee (flexion and extension), and muscle to determine whether differences existed between the I-EMG of 4 different closed chain exercises (unilateral one-quarter squat, lateral step-up, FlexCord front pull, and FlexCord back pull). The Tukey test was used for post hoc comparisons. Muscle and knee movement were treated as control variables for post hoc comparisons. The probability was set at $P \leq .05$ for all tests.

RESULTS

All results are summarized in the Table. We detected an overall difference between the exercises ($F_{3,35} = 17.99$, $P < .0001$). The FlexCord front-pull and FlexCord back-pull exercises produced higher levels of biceps femoris activity than the lateral step-up during knee extension (Tukey, $P < .05$). During knee flexion, the FlexCord front-pull and FlexCord back-pull exercises produced higher levels of biceps femoris activity than the unilateral one-quarter squat and the lateral step-up exercises (Tukey, $P < .05$). The FlexCord front pull also produced higher levels of vastus medialis activity than the unilateral one-quarter squat, lateral step-up, and FlexCord back pull during knee extension (Tukey, $P < .05$).

DISCUSSION

Many authors[1,10–14] recommend closed chain exercises as an effective, safe, and functional ACL rehabilitation tool. Shelborne et al[1,13] suggested a program consisting of early full hyperextension, early weightbearing, and early increases in functional strength through closed chain exercises. Often

Means ± Standard Deviations of EMG Measurements (mV · s · 10³)

Muscle	Exercise	Flexion	Extension
Biceps femoris			
	Back pull	100.28 ± 71.7*	137.10 ± 144.0*
	Front pull	105.00 ± 67.6*	147.43 ± 97.2*
	Quarter squat	50.37 ± 31.5	54.96 ± 5.6
	Step-up	59.18 ± 27.6	57.75 ± 30.7
Vastus lateralis			
	Back pull	314.73 ± 149.5	203.68 ± 115.0
	Front pull	317.92 ± 145.2	211.40 ± 88.7
	Quarter squat	301.80 ± 200.8	162.30 ± 68.7
	Step-up	258.63 ± 115.4	158.23 ± 73.2
Vastus medialis			
	Back pull	233.85 ± 104.8	164.89 ± 63.7
	Front pull	249.40 ± 96.1	192.49 ± 67.8†
	Quarter squat	270.09 ± 129.4	140.20 ± 56.7
	Step-up	220.90 ± 83.8	149.70 ± 50.8

*Activity greater than quarter squat and step-up ($P < .05$).
† Activity greater than quarter squat, step-up, and FlexCord back pull ($P < .05$).

during this aggressive rehabilitation protocol, these closed chain exercises must be performed through a limited pain-free range of motion. The closed chain exercises in this study were performed as they would be in the clinical setting, allowing for approximately 5° to 30° of knee flexion.

Hypothetically, during the front-pull exercise, the pull of the elastic cord tends to cause knee extension and hip flexion in the dominant or closed chain leg. By performing the front pull, the closed chain leg resists these actions, and, therefore, the hamstrings are activated. The hamstrings of the closed chain or dominant leg are recruited to maintain upright posture and resist the pull from the elastic tubing on the open chain leg during the exercise. If the hamstrings were not recruited, the subject would simply fall over. Metzger[5] suggested that, by overloading the semitendinosus and the biceps femoris more than the vastus lateralis and the vastus medialis, the FlexCord front pull provides a safe means of activating the quadriceps because of the strong cocontraction of the hamstrings. Our results agree: the biceps femoris was more active during the flexion and extension portions of the front pull, compared with the flexion and extension portions of the unilateral one-quarter squat and the lateral step-up.

The FlexCord front pull may, in fact, be a safer exercise for the ACL graft than the traditional one-quarter squat and the lateral step-up because of the high degree of hamstring activity. This suggestion assumes, however, that the biceps femoris fires solely as a cocontractor. It is possible that the force generated by the posterior pull of the elastic tubing on the open chain leg causes an increased anterior shear force on the closed chain knee. As the tibia of the closed chain leg remains stable, the distal end of the femur could move posteriorly on the tibia, causing an anterior shear force. The hamstrings could possibly fire as a result of the shear force.

The FlexCord front pull also produced significantly higher vastus medialis activity during extension than the unilateral one-quarter squat, lateral step-up, and FlexCord back pull. Since the FlexCord front pull recruits the vastus medialis more than the other 3 exercises during extension, it could be a beneficial exercise, relative to the other exercises in our study, for patellofemoral rehabilitation. This could also be a benefit in preventing patellofemoral problems secondary to ACL reconstruction that often slow the rehabilitation process. More study is needed to investigate its efficacy.

The FlexCord exercises had the advantage in this study of providing additional resistance through the open chain leg. However, the action of the closed chain leg remains the same as the one-quarter squat and the step-up. Although there was only 1 difference found in quadriceps activity between the exercises, it is important to point out that the FlexCord exercises studied here are comparable with the one-quarter squat and step-up in both action and vertical loading. The horizontal resistance that is added during the FlexCord exercises merely disturbs the same 30° arc that is performed in each of the exercises. With this, the FlexCord exercises add the benefit of increased hamstring activity, which is of great help in rehabilitation after ACL reconstruction.

EMG activity may not be directly related to muscle and joint forces. According to Solomonow et al,[19] the relationship between EMG activity and muscle forces depends on firing rate, recruitment patterns, muscle fiber type, muscle length, and contraction rate. Another factor is the type of contraction, concentric or eccentric, which cannot be distinguished from the simple EMG signal. Several authors,[20–27] on the other hand, advocate the use of EMG measurements to interpret muscle force. With proper experimental control and under certain experimental conditions, muscle force could be calculated.[28] Marras[28] stated that the following experimental conditions must be met to interpret muscle force from EMG measurements: the muscle must be in a static or controlled dynamic state; the EMG-force relationship must be qualified according to unique properties of the muscle; and a given portion of the muscle must be sampled because factors like the length-tension relationship of muscle may confound the EMG-force relationship. Our study accomplished these criteria by controlling the rate of movement in each exercise through the use of a metronome, by measuring the movement (flexion and extension) of each exercise independently, and by having each subject perform each of the exercises without removing the electrodes.

There are a few possible explanations for the large difference in EMG measurements between subjects. First, each subject, while healthy and active, is unique in weight, coordination, and recruitment patterns. The second factor that seemed to play a large role was each subject's ability to perform all the exercises correctly and synchronized with the metronome. Although all subjects had an initial practice session, some differences were noted in how precisely the exercises were performed. Most subjects were able to coordinate the movements associated with all 4 exercises, while some had difficulty coordinating movements for the FlexCord exercises. A balanced latin square was used to account for learning or fatigue effects, but variations in exercise between subjects were still present. Another factor could have been start-time variability. The subject was asked to start on a command, at which time the EMG was also started. To counteract this, the first and last thirds of each measurement were thrown out, and the middle third was analyzed. Additionally, a mean of 3 trials was used for analysis. Some variability may have been the result of peak activity occurring before or after the middle third of the recording. However, the data appeared consistent in that the greatest activity was within the middle third of the recording.

All subjects in this study were healthy. We cannot conclude that these exercises would give the same results for pathologic subjects because of different recruitment patterns. We will, however, make a few recommendations.

Clinical Recommendations

The FlexCord exercises, specifically the front pull and back pull, are good alternative closed chain exercises for general knee rehabilitation in the very early stages of rehabilitation, while range of motion is limited. The FlexCord exercises produce as much activity in the quadriceps as the traditional exercises studied (one-quarter squat and step-up), and they also produce a biceps femoris contraction. The latter of these points must be taken conservatively with respect to the anterior shear forces we spoke of earlier. It should also be noted that our study does not confirm the effectiveness of any of these exercises. However, these are commonly used exercises at an early stage of rehabilitation, and this study does show which exercise activates the 3 muscles (vastus lateralis, vastus medialis, and biceps femoris) the most, relative to the other exercises.

REFERENCES

1. Shelbourne KD, Rowdon GA. Anterior cruciate ligament injury: the competitive athlete. *Sports Med.* 1994;17:132–140.
2. Cook T, Zimmermann C, Lux K, Neubrand C, Nicholson T. EMG comparison of lateral step-up and stepping machine exercises. *J Orthop Sports Phys Ther.* 1992;16:108–112.
3. Graham VL, Gehlsen GM, Edwards JA. Electromyographic evaluation of closed and open kinetic chain knee rehabilitation exercises. *J Athl Train.* 1993;28:23–30.
4. Lutz GE, Palmitier RA, An KN, Chao EYS. Comparison of tibiofemoral joint forces during open-kinetic-chain and closed-kinetic-chain exercises. *J Bone Joint Surg Am.* 1993;75:732–739.
5. Metzger KJ. *An Electromyographic Investigation of Four Elastic Tubing Closed Kinetic Chain Exercises After ACL Reconstruction* [master's thesis]. Provo, UT: Brigham Young University; 1996.
6. Schaub PA, Worrell TW. EMG activity of six muscles and VMO:VL ratio determination during a maximal squat exercise. *J Sport Rehabil.* 1995;4:195–202.
7. Wilk KE, Escamilla RF, Fleisig GS, Barrentine SW, Andrews JR, Boyd ML. A comparison of tibiofemoral joint forces and electromyographic activity during open and closed kinetic chain exercises. *Am J Sports Med.* 1996;24:518–527.
8. Yack HJ, Collins CE, Whieldon TJ. Comparison of closed and open kinetic chain exercise in the anterior cruciate ligament-deficient knee. *Am J Sports Med.* 1993;21:49–54.
9. Zimmermann CL, Cook TM, Bravard MS, et al. Effects of stair-stepping exercise direction and cadence on EMG activity of selected lower extremity muscle groups. *J Orthop Sports Phys Ther.* 1994;19:173–180.
10. Chu DA. Rehabilitation of the lower extremity. *Clin Sports Med.* 1995;14:205–222.
11. Frndak PA, Berasi CC. Rehabilitation concerns following anterior cruciate ligament reconstruction. *Sports Med.* 1991;12:338–346.
12. Paulos LE, Wnorowski DC, Beck CL. Rehabilitation following knee surgery: recommendations. *Sports Med.* 1991;11:257–275.
13. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med.* 1990;18:292–299.
14. Shelbourne KD, Klootwyk TE, Wilckens JH, DeCarlo MS. Ligament stability two to six years after anterior cruciate ligament reconstruction with autogenous patellar tendon graft and participation in accelerated rehabilitation program. *Am J Sports Med.* 1995;23:575–579.
15. Baratta R, Solomonow M, Zhou BH, Letson D, Chuinard R, D'Ambrosia R. Muscular coactivation: the role of the antagonist musculature in maintaining knee stability. *Am J Sports Med.* 1988;16:113–122.
16. Bynum EB, Barrack RL, Alexander AH. Open versus closed chain kinetic exercises after anterior cruciate ligament reconstruction: a prospective randomized study. *Am J Sports Med.* 1995;4:401–406.
17. Ohkoshi Y, Yasuda K, Kaneda K, Wada T, Yamanaka M. Biomechanical analysis of rehabilitation in the standing position. *Am J Sports Med.* 1991;19:605–611.
18. LeVeau B, Andersson GBJ. Data analysis and applications. In: *Selected Topics in Surface Electromyography for Use in the Occupational Setting: Expert Perspectives.* Atlanta, GA: US Department of Health and Human Services, Public Health Services, Centers for Disease Control; 1992:70–73. Publication No. 91-100.
19. Solomonow M, Baratta R, Shoji H, D'Ambrosia R. The EMG-force relationships of skeletal muscle: dependence on contraction rate and motor units control strategy. *Electromyogr Clin Neurophysiol.* 1990;30:141–152.
20. DeJong RH, Freund FG. Relation between electromyogram and isometric twitch tension in human muscle. *Arch Phys Med Rehabil.* 1967;48:539–542.
21. DeVries HA. "Efficiency of electrical activity" as a physiological measure of the functional state of muscle tissue. *Am J Phys Med.* 1968;47:10–22.
22. Komi PV, Buskirk ER. Reproducibility in electromyographic measurements with inserted wire electrodes and surface electrodes. *Electromyography.* 1970;4:357–367.
23. Kuroda E, Klissouras V, Milsum JH. Electrical and metabolic activities and fatigue in human isometric contraction. *J Appl Physiol.* 1970;29:358–367.
24. Lawrence JH, DeLuca CJ. Myoelectric signal versus force relationship in different human muscles. *J Appl Physiol.* 1983;54:1653–1659.
25. Lippold OJC. The relationship between integrated action potentials in the human muscle and its isometric tension. *J Physiol (Lond).* 1952;117:492–499.
26. Woods JJ, Bigland-Ritchie B. Linear and non-linear surface EMG/force relationships in human muscles: an anatomical/functional argument for the existence of both. *Am J Phys Med.* 1983;62:287–299.
27. Zuniga EN, Simons EG. Nonlinear relationship between averaged electromyogram potential and muscle tension in normal subjects. *Arch Phys Med Rehabil.* 1969;50:613–620.
28. Marras W. Applications of electromyography in ergonomics. In: *Selected Topics in Surface Electromyography for Use in the Occupational Setting: Expert Perspectives.* Atlanta, GA: US Department of Health and Human Services, Public Health Services, Centers for Disease Control; 1992:123–136. Publication No. 91-100.

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Reliability and Effects of Arm Dominance on Upper Extremity Isokinetic Force, Work, and Power Using the Closed Chain Rider System

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Objective: The purpose of our study was to assess the reliability of the Closed Chain Rider System between exercise sessions and to determine the effects of arm dominance using muscle force, work, and power measures during closed chain chest-press exercise.

Design and Setting: Sitting subjects underwent identical testing on 2 occasions and performed 5 reciprocal chest-press movements at speeds of 51 and 76 cm/s.

Subjects: Thirty-eight healthy college students.

Measurements: Average force, total work, average power, and linear range of motion were recorded. Reliability was evaluated by calculating intraclass correlation coefficients. Mean differences between the dominant and nondominant arms for the measured variables were analyzed by dependent *t* tests.

Results: For both the dominant and nondominant arms at the 51 and 76 cm/s speeds, reliabilities of average force (range = 0.85 to 0.91), total work (range = 0.88 to 0.92), and average power (range = 0.86 to 0.89) were clinically acceptable. The dominant arm produced significantly greater average force, total work, and average power compared with the nondominant arm.

Conclusions: Our results provide clinically useful information about the reliability of force, work, and power measures during multijoint bilateral chest-press movement. Clinicians should be aware of measured differences between dominant and nondominant arms.

Key Words: isokinetic testing, closed kinetic chain, arm strength

Strength training is considered an integral part of upper extremity and shoulder rehabilitation. A popular strength training method is closed kinetic chain exercise, which involves movement when the distal limb segment is fixed, body weight is supported by the extremity, or considerable external resistance is applied to the foot or hand.[1–3] In an attempt to apply the closed chain concept to the upper extremity, several researchers have proposed different classification systems of closed kinetic chain exercise to define and develop closed chain activities for upper extremity rehabilitation.[3–6] For example, Dillman et al[4] provided a classification system that is based on the mechanics of the particular exercise where the boundary condition of the distal limb segment may be either fixed or movable, whereas the external load may or may not be present at the distal segment. For the purpose of rehabilitation, closed chain strengthening exercise is performed to promote coactivation of stabilizing muscles, minimize shear forces, stimulate proprioceptors in the involved joints, provide large-resistance and low-acceleration movements, and promote dynamic stabilization.[3]

The need exists for clinically objective and reliable measures of muscle function in a closed kinetic chain movement pattern. The Closed Chain Rider System (Mettler Electronics, Anaheim, CA) is an integrated, computer-controlled, closed chain exercise and muscle evaluation system that provides isokinetic accommodating resistance with distal loading. A unique aspect of this system is the linear resistance that is produced during alternating multijoint movements at various velocities. Reliability using intraclass correlation coefficients for this system has been reported employing the legs for average force (range = 0.76 to 0.90) and total work (range = 0.79 to 0.99).[7] Measurements were reported to be clinically acceptable, regardless of the testing speed or limb. No studies have established the reliability of measurement for the upper extremity using the Closed Chain Rider System. The purpose of our study was to establish test-retest reliability using bilateral alternating chest-press movements and to examine the effects of limb dominance using muscle force, power, and work parameters during a closed chain chest-press exercise.

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METHODS

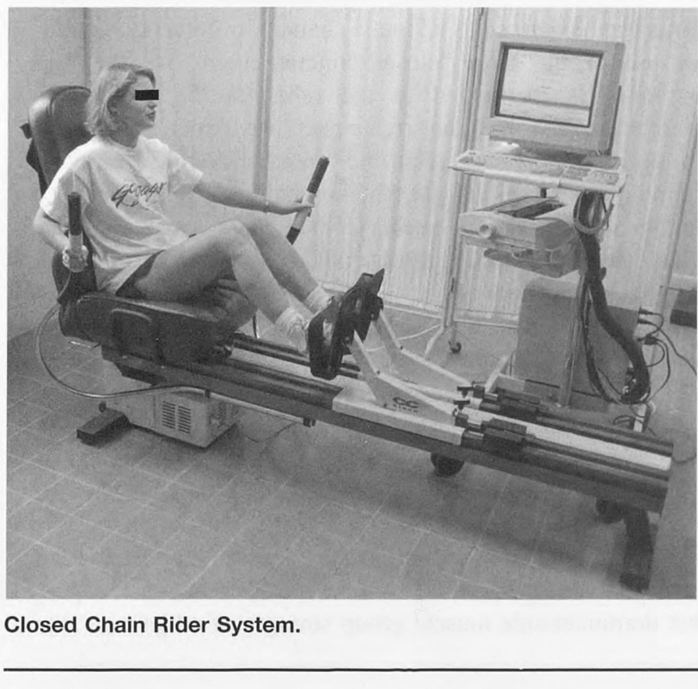
Subjects

Thirty-eight (males = 19, females = 19) healthy college students (age = 22.3 ± 2.9 years, wt = 72.7 ± 17.7 kg, ht = 168.5 ± 8.4 cm) volunteered to participate. Each subject refrained from participating in heavy-resistance weight and endurance training during the study, although the usual recreational and daily activities were allowed. Subjects refrained from vigorous exercise during the 24 hours before testing. In compliance with institutional guidelines, the study was approved by the University of South Alabama Institutional Review Board, and subjects read and signed an informed consent before data collection.

Instrumentation

Testing of the right and left upper extremities was conducted using the Closed Chain Rider System. The Closed Chain Rider System consists of 2 rail extensions that contain channels for the movement of rubber-wheeled rollers attached to a tubular handle (Figure). When engaged, the arm couplers are connected by a chain-and-sprocket system to a motor that provides the braking action for accommodating resistance during exercise. Computer software controls the braking action of the system.

The seat back was reclined to approximately 100° during testing. Subjects were secured in the seat by a pelvic strap for pelvic immobilization, along with chest straps placed over the shoulder and across the chest to stabilize the torso. The feet were placed into foot pads, secured, and locked into place with the knees positioned at a 90° flexion angle so that no movement of the lower extremity occurred during testing. During each testing session, the subjects grasped the tubular handles attached to both sides of the rail extensions approximately 5 cm from the top of the handle. Subjects performed an alternating unilateral pushing motion consisting of shoulder flexion and elbow extension, followed by the reciprocal motion of the contralateral extremity. Subject positioning and testing was performed as described in the Closed Chain Rider System instruction manual.[8]



Closed Chain Rider System.

Protocol

Subjects participated in 1 pretest and 2 test sessions, each separated by 5 to 7 days. The pretest session was used to introduce the Closed Chain Rider to the subjects, provide practice exercise, measure body weight and height, and determine arm dominance. Subjects were asked whether they were right or left handed in order to establish arm dominance. The subjects then performed 2 sets of 10-repetition reciprocating chest-press movements (shoulder flexion, elbow extension) at each testing speed to become familiar with the apparatus.

The 2 testing sessions were identical for all subjects. Before testing, a 3-minute warm-up on a hand-crank ergometer was performed. A total of 3 to 5 submaximal chest-press repetitions preceded testing at each of the 2 speeds. During each test session, 5 repetitions of alternating maximal chest-press movements at speeds of 51 and 76 cm/s (20 and 30 in/s) were performed. Subjects were instructed to perform each chest-press movement as fast and as hard as possible after hearing the word "go." A 1-minute rest period separated testing at each speed. The order of testing during the 2 days was randomly assigned and balanced using 2 different progression orders. For order 1, the 51-cm/s speed was tested first, and, for order 2, the 76-cm/s speed was tested first.

Statistical Analysis

Of the 5 repetitions performed at each speed, the first repetition was excluded from the data analysis to standardize the range of motion so that work values could be calculated.[8,9] Thus, data analysis was performed using the mean value of 4 repetitions in the statistical analysis. Test-retest reliability for average force (kg), total work (J), and average power (W) was evaluated by calculating intraclass correlations (ICC 2,1).[10] An ICC value of 0.75 or greater was considered high and clinically acceptable.[10] The standard error of measurement (SEM) was calculated as a measure of variability expected in subjects' scores.

A dependent t test was conducted to test the null hypothesis of no difference between dominant and nondominant limbs for average force, total work, and average power on day 1. A 2-tailed test at the 0.05 level of significance was used for all tests. Means and standard deviations (SDs) were used to describe the data.

RESULTS

The mean value ($\pm$SD), reliability coefficients, and standard errors for average force, total work, and average power are presented in Table 1. The reliabilities of average force (range = 0.85 to 0.91), total work (range = 0.88 to 0.92), and average power (range = 0.86 to 0.89) measurements were clinically acceptable regardless of the testing speed or arm.[10] The dominant arm produced greater ($P \leq .05$) average force, total work, and average power than the nondominant arm regardless of speed (Table 2). Average linear range of motion

Table 1. Average Force, Total Work, and Average Power for Dominant and Nondominant Arms

Variable	Day 1 (Mean ± SD)	Day 2 (Mean ± SD)	ICC (2,1)*	SEM†
Speed = 51 cm/s				
Average force (kg)				
Dominant arm	11.79 ± 4.4	11.42 ± 4.2	0.89	1.43
Nondominant arm	10.37 ± 4.0	10.47 ± 4.2	0.91	1.23
Total work (J)				
Dominant arm	192.32 ± 84.9	184.58 ± 81.4	0.92	23.52
Nondominant arm	167.34 ± 79.4	169.18 ± 79.1	0.92	22.42
Average power (W)				
Dominant arm	44.11 ± 19.3	42.84 ± 17.6	0.88	6.39
Nondominant arm	38.55 ± 17.6	40.00 ± 17.8	0.89	5.87
Speed = 76 cm/s				
Average force (kg)				
Dominant arm	9.71 ± 4.4	9.37 ± 3.8	0.88	1.42
Nondominant arm	8.63 ± 3.9	8.66 ± 3.5	0.85	1.43
Total work (J)				
Dominant arm	173.92 ± 86.7	162.24 ± 79.9	0.90	26.34
Nondominant arm	154.39 ± 79.9	149.97 ± 71.3	0.88	26.19
Average power (W)				
Dominant arm	44.97 ± 23.8	41.63 ± 21.4	0.86	8.46
Nondominant arm	40.13 ± 21.8	38.74 ± 19.8	0.83	8.58

*Intraclass correlation coefficient.
†Standard error of measurement.

Table 2. *t*-Test Comparisons and Percentage Differences Between Dominant and Nondominant Arms for Average Force, Total Work, Average Power, and Range of Motion for Day 1

Variable	Dominant (Mean ± SD)	Nondominant (Mean ± SD)	Percentage Difference	*t* Value	*P* Value
Speed = 51 cm/s					
Average force (kg)	11.79 ± 4.4	10.37 ± 4.0	12.0%	5.19	.001
Total work (J)	192.32 ± 84.9	167.34 ± 79.4	13.0%	5.78	.001
Average power (W)	44.11 ± 19.3	38.55 ± 17.6	12.6%	4.80	.001
Range of motion (cm)	105.82 ± 13.7	105.21 ± 11.9	0.6%	1.07	.291
Speed = 76 cm/s					
Average force (kg)	9.71 ± 4.4	8.63 ± 3.9	11.1%	4.95	.001
Total work (J)	173.92 ± 86.7	154.39 ± 79.9	11.2%	5.27	.001
Average power (W)	44.97 ± 23.8	40.13 ± 21.8	10.8%	4.20	.001
Range of motion (cm)	113.89 ± 15.0	114.50 ± 15.5	0.5%	0.55	.583

was not significantly different between the dominant and nondominant arms for the testing speeds ($P \geq .05$) (Table 2).

DISCUSSION

If closed kinetic chain isokinetic dynamometry is to be used for muscle performance testing, it must demonstrate test-retest reliability.[7,11] Several published reports show open kinetic chain isokinetic assessment of upper extremity muscle groups to be very reliable, with reliability coefficients for shoulder internal-external rotation peak torque ranging from 0.80 to 0.93 and those for shoulder flexion-extension ranging from 0.75 to 0.95.[12–14] The reliability coefficients we found using the Closed Chain Rider System were very similar to those reported using isolated open kinetic chain motions, despite the bilateral alternating multijoint movement that occurred during the closed kinetic chain exercise.

In the upper extremity, the scapulothoracic articulation and the acromioclavicular, sternoclavicular, and glenohumeral joints can be defined as a kinetic chain.[3] Controversy regarding the use of the term "closed kinetic chain" for the upper extremity is mentioned in the rehabilitation literature.[3,15] Weightbearing forces that create the closed kinetic chain effect do not normally occur in the upper extremity. However, Steindler[2] reported that the kinetic chain concept exists in the human when the hand meets considerable resistance versus when it is free to move, as observed in the open kinetic chain. Hand placement in the closed chain position changes neuromuscular activation due to differences in proprioceptor stimulation, muscle action, and joint compressive forces.[16–19] Clearly, many athletic activities, such as football, wrestling, and gymnastics, require the upper extremity to function as a closed kinetic chain.[15]

The 12% strength differences between dominant and nondominant arms that we observed make closed kinetic chain bilateral comparisons inappropriate because natural differences exist between extremities. For example, Perrin et al[20] reported that dominant-side muscle group strength of athletes in asymmetric upper extremity activities, such as throwing, may be up to 15% greater than the strength of the nondominant side. This difference in muscle performance between the dominant and nondominant limbs may affect the criteria for return of the injured extremity to a normal state during rehabilitation. Additional information on muscle force, work, and power during closed kinetic chain isokinetic exercise is needed so that appropriate rehabilitation norms can be established. Future studies should examine the efficacy of isokinetic closed chain exercise for pathologies involving the glenohumeral and scapulothoracic joints and should substantiate guidelines for use.

CONCLUSIONS

Regardless of testing speed or arm used during a concentric chest-press exercise pattern with the Closed Chain Rider System, the reliabilities of average force, total work, and average power were clinically acceptable. Clinicians should understand that natural limb differences exist between dominant and nondominant arms when tested in a closed kinetic chain.

REFERENCES

1. Steindler A. *Kinesiology of the Human Body.* Springfield, IL: Charles C. Thomas; 1955.
2. Steindler A. *Kinesiology of the Human Body Under Normal and Pathological Conditions.* Springfield, IL: Charles C. Thomas; 1977.
3. Lephart SM, Henry TJ. The physiological basis for open and closed kinetic chain rehabilitation for the upper extremity. *J Sport Rehabil.* 1996;5:71–87.
4. Dillman CJ, Murray TA, Hintermeister RA. Biomechanical differences of open and closed chain exercises with respect to the shoulder. *J Sport Rehabil.* 1994;3:228–238.
5. Gray GW. *Chain Reaction: Successful Strategies for Closed Chain Testing and Rehabilitation.* Adrain, MI: Wynn Marketing; 1989.
6. Panariello RA. The closed kinetic chain in strength training. *Natl Strength Cond Assoc J.* 1991;13:29–33.
7. Kovaleski JE, Heitman RJ, Gurchiek LR, Erdmann JW, Trundle TL. Reliability and effects of leg dominance on lower extremity isokinetic force and work using the Closed Chain Rider System. *J Sport Rehabil.* 1997;6:319–326.
8. *Closed Chain Rider Instruction Manual.* Anaheim, CA: Mettler Electronics Corp; 1995.
9. Kovaleski JE, Heitman RJ, Scaffidi FM, Fondren FB. Effects of isokinetic velocity spectrum exercise on average power and total work. *J Athl Train.* 1992;27:54–56.
10. Shrout PE, Fleiss JL. Intraclass correlation: uses in assessing rater reliability. *Psychol Bull.* 1979;86:420–428.
11. Davies GJ, Heiderscheit BC. Reliability of the Lido Linea closed kinetic chain isokinetic dynamometer. *J Orthop Sports Phys Ther.* 1997;25:133–136.
12. Hageman PA, Mason DK, Rydlund KW, Humpal SA. Effects of position and speed on eccentric and concentric isokinetic testing of the shoulder rotators. *J Orthop Sports Phys Ther.* 1989;11:64–69.
13. Hellwig EV, Perrin DH. A comparison of two positions for assessing shoulder rotator peak torque: the traditional frontal plane versus the plane of the scapula. *Isokinetic Exerc Sci.* 1991;1:1–5.
14. Perrin DH. Reliability of isokinetic measures. *Athl Train, JNATA.* 1986; 10:319–321.
15. Wilk KE, Arrigo CA, Andrews JR. Closed and open kinetic chain exercise for the upper extremity. *J Sport Rehabil.* 1996;5:88–102.
16. Borsa PA, Lephart SM, Kocher MS, Lephart SP. Functional assessment and rehabilitation of shoulder proprioception for glenohumeral instability. *J Sport Rehabil.* 1994;3:84–104.
17. Bradley JP, Tibone JE. Electromyographic analysis of muscle action about the shoulder. *Clin Sports Med.* 1991;10:789–805.
18. Davies GJ, Dickoff-Hoffman S. Neuromuscular testing and rehabilitation of the shoulder complex. *J Orthop Sports Phys Ther.* 1993;18:449–458.
19. Moseley JB, Jobe FW, Pink M, Perry J, Tibone J. EMG analysis of the scapular muscles during a shoulder rehabilitation program. *Am J Sports Med.* 1992;20:128–134.
20. Perrin DH, Robertson RJ, Ray RL. Bilateral isokinetic peak torque, torque acceleration energy, power, and work relationships in athletes and nonathletes. *J Orthop Sports Phys Ther.* 1987;9:184–189.

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Proprioception and Neuromuscular Control of the Shoulder After Muscle Fatigue

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Objective: To examine the effects of fatigue on proprioception and neuromuscular control of the shoulder.

Design and Setting: Subjects were randomly assigned to either an experimental group or control group. Subjects were tested using either the active angle-reproduction or the single-arm dynamic stability test. The subjects were then fatigued using a dynamometer performing continuous, concentric rotation exercises of the shoulder. Once fatigued, the subjects were posttested using the same test. One week later, the subjects returned and were pretested, fatigued, and posttested using the other test.

Subjects: Thirty-two college-age (18 to 25 years) subjects (16 males, 16 females) with no history of glenohumeral instability or upper extremity injury volunteered for this study.

Measurements: Absolute angular error was measured using an electrogoniometer present within the isokinetic dynamometer, while sway velocity was measured using a force-plate system.

Results: Repeated-measures analysis of variance revealed a significant difference between the pretest and posttest values for absolute angular error in the experimental group, whereas no significant difference was revealed between pretest and posttest sway velocity for either the control or experimental group.

Conclusions: Fatigue of the internal and external rotators of the shoulder decreased proprioception of the shoulder, while having no significant effect on neuromuscular control.

Key Words: mechanoreceptors, joint position sense, force plate

Since proprioception is a component of neuromuscular control, the two terms are often used interchangeably and incorrectly. Proprioception is defined as the specialized variation of the sensory modality of touch that encompasses the sensation of joint movement (kinesthesia) and joint position,[1] whereas neuromuscular control is the unconscious motor efferent response to afferent sensory (proprioceptive) information.

Afferent proprioceptive feedback results from impulses transmitted by mechanoreceptors to the central nervous system (CNS), relaying information about joint position and joint movement sense.[1] A mechanoreceptor is a specialized neuroepithelial structure found in the skin and in articular, ligamentous, muscular, and tendinous tissue about a joint.[2] Mechanoreceptors transduce functional and mechanical deformation into frequency-modulated neural signals. An increase in deformation causes an increase in afferent discharge of neural signals back to the CNS.[3]

Several studies to date have examined proprioception of the shoulder. Smith and Brunolli[4] compared the proprioceptive feedback of the involved versus the uninvolved shoulders in individuals who had sustained anterior dislocations. They concluded that proprioceptive deficits existed within the involved shoulder. Lephart et al[1] reported similar results when comparing shoulder proprioception of normal, unstable, and surgically repaired shoulders. Like Smith and Brunolli,[4] Lephart et al[1] reported proprioceptive deficits in both threshold to detection of passive motion and passive reproduction of joint position in persons with unstable shoulders, while differences between those with normal and surgically repaired shoulders were nonsignificant.

Since mechanoreceptors, which are responsible for proprioceptive feedback causing neuromuscular responses, are present in the musculature surrounding the joint,[2] it is feasible to believe that, as a muscle fatigues, proprioceptive feedback is affected, and thereby, neuromuscular control and shoulder function are affected. To date, 3 studies have examined the effect of fatigue on shoulder proprioception. Voight et al[5] studied the effects of fatigue and the relationship of arm dominance to shoulder proprioception. Using both active and passive joint-angle reproduction, they concluded that fatigue significantly decreased one's ability to both actively and passively reproduce an angle.[5] Voight et al[5] believed that the decrease in ability after fatigue was due to "dysfunctional mechanoreceptors" in the internal and external rotators of the shoulder. Carpenter et al[6] used threshold to detection of passive movement to determine how fatigue affects proprioception of the shoulder. These researchers concluded that fatigue affects sensation of joint movement, decreases athletic performance, and increases fatigue-related shoulder dysfunction.[6] Pedersen et al[7] measured joint position sense of the shoulder. Unlike Voight et al,[5] who measured shoulder

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proprioception with humeral rotation, Pedersen et al[7] assessed proprioception with shoulder motion in the transverse plane. Like Voight et al,[5] Pedersen et al[7] reported a decrease in joint position-sense ability after fatigue. While there is debate as to whether fatigue affects proprioception,[8,9] some studies have shown decreased proprioceptive feedback after bouts of fatigue.[5–7,10,11]

To date, these studies have examined the effect of fatigue on shoulder proprioception, but no investigators have examined how fatigue affects neuromuscular control of the shoulder joint. The purpose of our study was to determine how muscle fatigue affects shoulder proprioception and neuromuscular control of the shoulder joint. A study of this nature, focusing on both afferent proprioceptive feedback and the efferent neuromuscular responses, will shed light on how fatigue affects proprioceptive feedback, and thereby, neuromuscular control of the shoulder.

METHODS

Subjects

Subjects consisted of 32 physically active college students (16 males, age = 21.82 ± 1.46 years, weight = 81.42 ± 19.27 kg, height = 181.31 ± 5.59 cm; 16 females, age = 20.82 ± 1.44 years, weight = 56.08 ± 6.95 kg, height = 164.95 ± 6.50 cm) with no history of glenohumeral pathology. Subjects were randomly assigned to either an experimental group or a control group. Following the group assignment, subjects signed an informed consent form approved by the Institutional Review Board at the University of North Carolina at Chapel Hill, which also approved the study, and were instructed about the testing and fatigue procedures.

Instrumentation

Subjects performed the active angle-reproduction test (AAR) on the Lido Multi-Joint II isokinetic dynamometer (Loredan Biomedical, Inc, West Sacramento, CA). This test measures proprioceptive feedback using active reproduction of joint position. Lephart et al[12] reported that active joint position assessment stimulates both joint and muscle mechanoreceptors and is a more functional assessment of afferent pathways. We positioned the supine subjects in 90° of glenohumeral abduction with 90° of elbow flexion (Figure 1A). A hook-and-loop strap secured the subject's humerus to a pad positioned on the lever arm of the dynamometer, while the wrist was also secured to the lever arm. The subjects wore a pneumatic air splint, a blindfold, and headphones with music to eliminate tactile, visual, and auditory cues (Figure 1B).

The subjects performed the single-arm dynamic stability (SADS) test on the Smart Balance Master long force plate (NeuroCom International, Inc, Clackamas, OR) with the New Balance Master Version 6.1 software package (NeuroCom International, Inc). The test measures neuromuscular control by calculating sway velocity, which is a measure of amplitude divided by time. The amplitude is the distance (in degrees) traveled away from one's center of gravity, while time is the duration of the trial (10 seconds). The subjects assumed a single-arm push-up position with the dominant hand placed in the center of the force plate while the nondominant arm was placed on the small of the back. Full extension of the elbow, torso, hips, and knees was considered a correct position for testing. The subject positioned his or her feet in the center of the Dynamic Stabilization Trainer (DST 360; Exertool, San Carlos, CA) multidirectional unstable platform (Figure 2). We positioned the 40.64-cm unstable platform away from the center of the force plate at a distance corresponding to a measurement from the floor to the acromioclavicular joint of each subject. The unstable platform increased the difficulty of maintaining the single-arm push-up position.

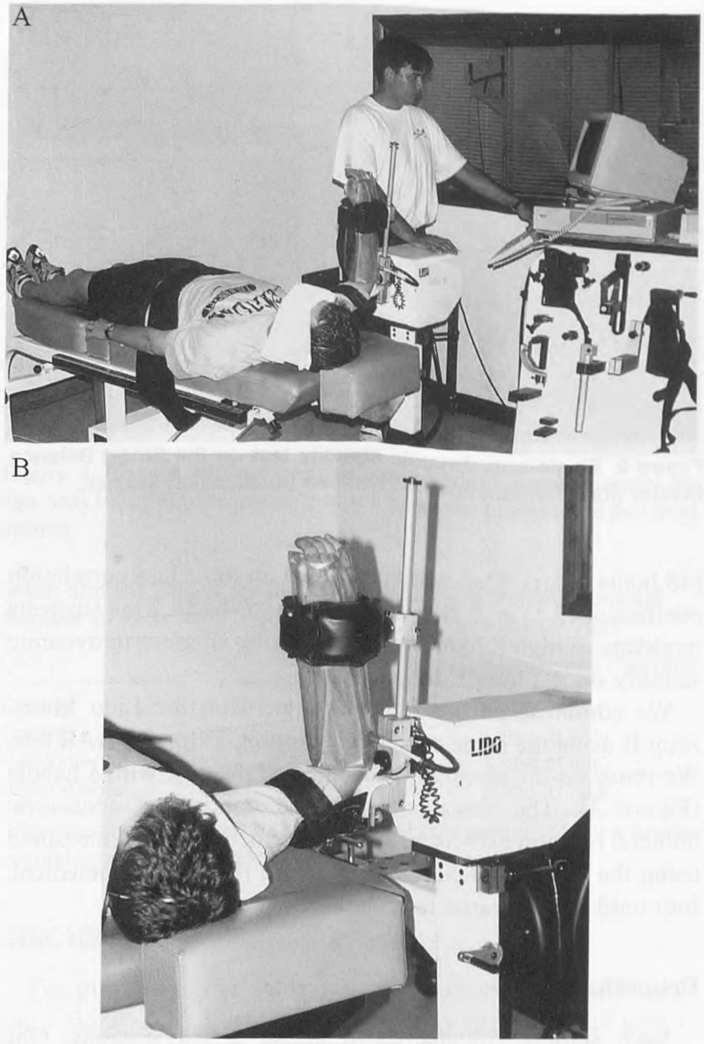

Figure 1. Active angle-reproduction test on the Lido Multi-Joint II. A, The supine subject is positioned in 90° of glenohumeral abduction and 90° of elbow flexion. B, A pneumatic air splint, blindfold, and headphones with music eliminate tactile, visual, and auditory cues.

We conducted a separate reliability study for the SADS test on 18 healthy, college-age subjects in 2 testing sessions

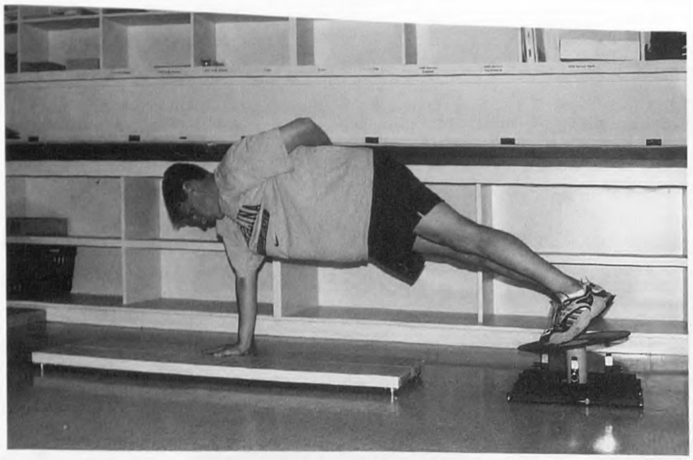

Figure 2. Single-arm dynamic stability test on the Smart Balance Master (long forceplate) and Dynamic Stabilization Trainer.

(48 hours apart). The results revealed an intraclass correlation coefficient (2,1) = 0.80 with an SEM of 0.253. This suggests moderate to high reliability for measuring single-arm dynamic stability on the long force plate.

We administered the fatigue protocol on the Lido Multi-Joint II using the same subject positioning as for the AAR test. We removed the air splint and replaced the cuff with a handle (Figure 3). The subjects performed continuous concentric humeral rotation exercises, and their peak torque was measured using the LIDOACT software package (Loredan Biomedical, Inc) until they became fatigued.

Procedures

Each subject volunteered to attend 2 test sessions. One session involved the proprioceptive testing procedure (AAR), and 1 session involved the neuromuscular control procedure (SADS). We counterbalanced the order of testing so that half the subjects performed AAR first, while half performed the SADS first. Before testing, all subjects performed a 2-minute warm-up activity using only the upper body to drive an ergometer. After the warm-up activity, we pretested the subjects using either the AAR or the SADS test.

Figure 3. Fatigue set-up on the Lido Multi-Joint II.

The AAR Test

We administered the AAR test to the dominant arm of all subjects. Before testing, we calibrated the electrogoniometer to correspond to 0° of humeral rotation for the subject. After calibration, we manually rotated the humerus into either an internally or externally rotated position, placing it at 1 of 3 reference angles (30° of internal rotation, 30° of external rotation, or 75° of external rotation). Because the articular mechanoreceptors are best stimulated at end ranges of motion, whereas muscle spindles, due to their gamma motor-neuron innervation, allow for readjustment of muscle tension and joint position sense at all times during activity,[13,14] we chose the 3 reference angles to represent both directions of humeral rotation, as well as midrange and end range of motion. We used various speeds (1°/s to 5°/s) of placement in an attempt to prevent anticipation. Once the reference angle was obtained, we held the position for 10 seconds and then passively returned the limb to 0° of rotation at the same speed previously used. We then instructed the subject to actively reproduce the reference angle. We standardized the dynamometer speed at 300°/s to ensure unrestricted motion by the subject. The isokinetic electrogoniometer measured the range of motion for each trial, allowing us to calculate absolute angular error (the absolute difference between the reference angle and the angle reproduced by the subject). The subjects performed 3 trials at each reference angle using a randomized testing order.

The SADS Test

The SADS test began after the subject assumed a push-up position, with the dominant hand placed on the center of the force plate and the feet on the DST 360. Each trial began once the subject placed the nondominant limb on the small of the back and closed his or her eyes. We instructed the subjects to remain as stable as possible for the 10-second trial period. The subjects performed 3 trials, with a 30-second rest period between trials. Pilot testing revealed that the experimental group subjects were apt to fall during testing. We defined a fall as 1) any type of touch down by the subject to help stabilize, or 2) the subject's leaving the force plate completely. A fall resulting from a touch down meant added stabilization due to an increased base of support and thereby affected the sway velocity score. If the subject fell off the force plate completely, causing the force plate to no longer detect weight, the test was stopped automatically, and the Smart Balance Master calculated no sway velocity score. The investigator substituted a value of 3.55°/s for all trials involving a fall. A pilot study in which 12 subjects remained as unstable as possible without falling, as well as performing several falls on the force plate, revealed that a mean value of 3.55°/s represented a fall.

After the pretest, the experimental group subjects immediately performed the fatigue protocol, using continuous concentric internal and external rotation exercises of the shoulder as described by both Voight et al[5] and Carpenter et al.[6] We standardized the dynamometer speed at 180°/s. We set range-of-motion restrictions at 85° of external rotation and 75° of internal rotation to limit excessive ranges of motion. The subjects performed continuous repetitions until the fatigue criterion was reached: 3 consecutive repetitions achieving less than 50% of the subject's maximum peak torque for external rotation. Control subjects performed no fatigue protocol and remained inactive for 5 minutes between the pretest and posttest. Immediately after the fatigue or 5-minute interval, we posttested the subjects using the pretest procedure.

After a 1-week layoff, the subjects returned to perform the remaining testing protocol (either AAR or SADS). During the second session, the subjects remained as control or experimental subjects, with only the testing protocol being changed. At the end of the second session, we analyzed data on each subject for both tests.

Data Analysis

The data were analyzed using repeated-measures analyses of variance calculated by the Statistical Package for Social Sciences (version 7.5; SPSS, Inc, Chicago, IL). Data for the AAR test were analyzed using a 1-between, 2-within repeated-measures design, whereas data from the single-arm dynamic stability test were analyzed using a 1-within, 1-between, repeated-measures design. We performed post hoc analyses with a Tukey calculation. The number of falls was analyzed using a Wilcoxon signed rank test. An a priori α level of 0.05 was set.

RESULTS

Shoulder proprioception was measured using the AAR test and quantified with absolute angular error. The control group achieved a mean absolute angular error value of 5.42° ± 2.94° for the pretest while scoring 5.02° ± 2.59° for the posttest. The experimental group's pretest mean absolute angular error was 4.72° ± 2.43°, and the posttest mean was 5.58° ± 2.23°. Statistical analysis revealed a group-by-test interaction ($F_{1,30}$ = 5.38, P = .027). Post hoc analysis revealed a significant difference between the pretest and posttest values for the experimental group, but no such significant difference for the control group (Figure 4).

We measured neuromuscular control of the shoulder using the SADS test (Table). No significant difference existed between SADS results before and after fatigue ($F_{1,30}$ = 2.49, P = .125). The Wilcoxon signed rank test analysis revealed a significant increase in the number of falls after fatigue by the experimental group (P = .016), but no significant difference between pretest and posttest falls for the control group (P = .317).

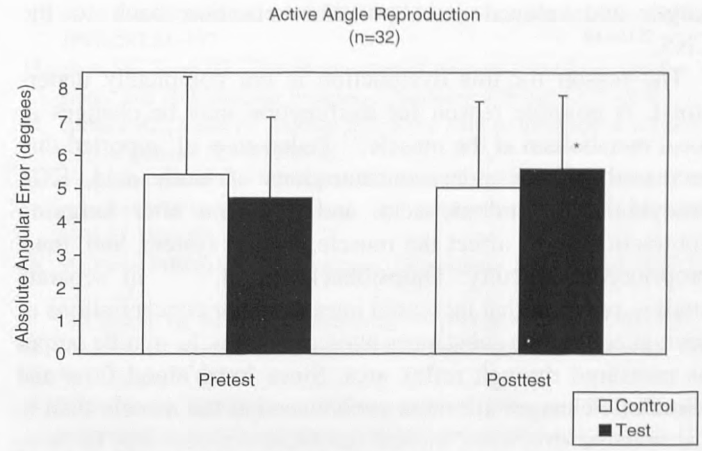

Figure 4. Pretest and posttest values (absolute angular error) for the AAR test. *Significant difference between pretest and posttest values.

Mean and SD Values for the Composite Sway Velocity and the Number of Falls for the Single-Arm Dynamic Stability Test

Group	Test	Falls	Mean Sway Velocity (°/s) (SD)
Control	Pretest	4	1.796 (0.651)
Control	Posttest	6	1.864 (0.685)
Experimental	Pretest	1	1.595 (0.496)
Experimental	Posttest	14*	2.095 (0.793)

*Significantly different from the number of falls exhibited by the experimental group during pretesting.

DISCUSSION

The purpose of our study was to determine whether fatigue had a significant effect on proprioceptive feedback and neuromuscular control of the shoulder. We hypothesized that fatigue would inhibit afferent proprioceptive feedback from the mechanoreceptors present in the muscle, thereby affecting neuromuscular control.

Shoulder Proprioception

Our results indicate that fatigue decreased proprioception of the shoulder as measured through joint position-sense assessment. Proprioceptive feedback regarding joint position results from mechanical stimulation of the mechanoreceptors present in the articular structures, muscles, and possibly skin.[2] Ruffini-type mechanoreceptors are predominant in all articular structures of the shoulder except the glenohumeral ligaments, where Pacinian corpuscle-type receptors are most abundant.[15] Muscle spindles and Golgi tendon organs are present in the muscle, with the muscle spindles more likely responsible for joint position sensation.[2] Nociceptors present in the skin at the joint may provide afferent feedback.[15] Since fatigue decreased the experimental group's ability to actively reproduce reference angles, we believe that muscle mechanoreceptors, specifically muscle spindles, are likely the primary receptors involved with joint position sense. As the subject moved into internal or external rotation, muscle spindles sensed changes in muscle length and relayed joint position sensation back to the CNS.[2,16–18]

The reason for this dysfunction is not completely understood. A possible reason for dysfunction may be changes in local metabolism at the muscle.[11] Pedersen et al[7] reported that increased intramuscular concentrations of lactic acid, KCl, bradykinin, arachidonic acid, and serotonin after fatiguing contractions may affect the muscle spindle system, and, thus, proprioceptive acuity. Djupsjöbacka et al,[19–21] in separate studies, reported that increased intramuscular concentrations of several contractile substances altered the muscle spindle output as measured through reflex arcs. Since local blood flow and metabolic changes are more pronounced at the muscle than in the articular structures, muscle mechanoreceptors may be more affected than articular mechanoreceptors.[11] This may cause one to rely primarily on proprioceptive information from the articular mechanoreceptors, thereby limiting joint repositioning ability. Both central and peripheral fatigue may also influence active angle reproduction. Central fatigue is due to influences of the CNS, whereas peripheral fatigue occurs at the level of the sarcomere and involves failure at the neuromuscular junction, sarcolemma, and transverse tubules.[22] The fatigue protocol may be taxing not only to the shoulder musculature but also to conscious joint position awareness. Unfortunately, the influences of central fatigue and peripheral fatigue are difficult to measure reliably.

Our findings support the "dysfunctional mechanoreceptor" theory proposed by Voight et al.[5] Muscle fatigue desensitized muscle spindle threshold, thereby decreasing afferent feedback to the central nervous system.[5] Carpenter et al[6] measured threshold to detection of passive motion after an isokinetic fatigue protocol. Threshold to detection of motion by the subjects increased after fatigue when compared with a control group. Carpenter et al[6] concluded that decreased proprioceptive sense after muscle fatigue might play a role in decreased athletic performance and shoulder dysfunction. We did not test threshold to detection of passive motion in our study because our isokinetic dynamometer's minimum velocity was 2°/s. Investigators often test threshold to detection of passive motion at a slower speed of 0.5°/s.[1,23,24]

Shoulder Neuromuscular Control

We quantified neuromuscular control by measuring the subject's ability to maintain the single-arm push-up position. The results of our study revealed no significant effect of fatigue on neuromuscular control of the shoulder joint and suggest that fatigue did not affect neuromuscular control when assessed by sway velocity. Although there was no significant effect on sway velocity, analysis of the number of falls revealed a significant increase in falls after fatigue in the experimental group, whereas no such difference existed in the control group.

It is difficult to definitively ascertain why the number of falls increased after fatigue compared with the control group. As shown in this study, fatigue decreased proprioception by affecting the mechanoreceptors present within the musculature of the shoulder. Neuromuscular control involves afferent proprioceptive feedback from peripheral mechanoreceptors. This afferent proprioceptive feedback is integrated at the CNS with input from both the visual and vestibular systems to produce spinal reflexes, cognitive programming, and balance, all of which affect muscle action through efferent responses.[25] Due to the compression of the humeral head in the glenoid fossa with the closed kinetic chain position, stimulation of the articular mechanoreceptors elicits a cocontraction response of the force-couple musculature.[26,27] Fatigue of the mechanoreceptors within the force-couple musculature affects cocontraction ability of the shoulder in the closed kinetic chain position, thereby affecting the subject's ability to maintain the single-arm push-up position. Again, we want to state that further research is needed to determine whether and how fatigue affected neuromuscular control in this study.

Clinical Significance

We believe the results from this study have clinical relevance. The subjects' ability to recognize joint position was hindered after a bout of isokinetic fatiguing exercise. The implications from decreased proprioception are threefold. First, afferent proprioceptive feedback integrated at the CNS elicits efferent neuromuscular responses as both spinal reflexes and preprogrammed responses vital to functional stability of the shoulder joint.[25,28] Because fatigue hinders proprioceptive feedback from the shoulder to the CNS, the neuromuscular responses responsible for joint stability may be hindered, leading to joint instability and eventually joint injury. Second, if a person's ability to recognize joint position, and more importantly extremes in joint position, is hindered, he or she may be prone to injury due to increased mechanical stress placed on both the static and dynamic structures responsible for joint stability. Finally, Carpenter et al[6] concluded that decreased proprioceptive sense after muscle fatigue might play a role in decreased athletic performance. As a person fatigues, a decrease in athletic performance may place an individual in harm's way in terms of injury.

Clinicians should consider modifications to rehabilitation protocols after shoulder injury, as well as preventive programs for individuals who are unstable. Oftentimes, rehabilitation programs contain the traditional 3 sets of 10-repetition protocols for resistive training. Because the musculature responsible for providing dynamic stability of the shoulder has a continual stabilization function, clinicians should incorporate endurance training-type exercises for the dynamic stabilizers of the glenohumeral joint into rehabilitation programs.

CONCLUSIONS

Our results indicate decreased proprioceptive feedback after fatigue of the shoulder musculature, whereas the effect of fatigue on neuromuscular control was inconclusive. Even though these results shed light on the effect of fatigue on shoulder proprioception, additional research is needed to fully understand how fatigue, as well as diminished proprioception, affects the efferent neuromuscular responses by the musculature that provides joint stability. It is extremely important for a joint to sense forces placed on the articular and muscular structures and respond appropriately with efferent feedback to the muscles, providing much-needed dynamic joint stability to the inherently unstable shoulder joint.

REFERENCES

1. Lephart SM, Warner JP, Borsa PA, Fu FH. Proprioception of the shoulder joint in healthy, unstable, and surgically repaired shoulders. *J Shoulder Elbow Surg.* 1994;3:371–380.
2. Grigg P. Peripheral neural mechanism in proprioception. *J Sport Rehabil.* 1994;3:2–17.
3. Lephart SM. Reestablishing proprioception, kinesthesia, joint position sense, and neuromuscular control in rehabilitation. In: Prentice WE, ed. *Rehabilitation Techniques in Sports Medicine.* 2nd ed. St. Louis, MO: Mosby; 1994:118–137.
4. Smith RL, Brunolli J. Shoulder kinesthesia after anterior glenohumeral dislocation. *Phys Ther.* 1989;69:106–112.
5. Voight ML, Hardin JA, Blackburn TA, Tippett S, Canner GC. The effects of muscle fatigue on and the relationship of arm dominance to shoulder proprioception. *J Orthop Sports Phys Ther.* 1996;23:348–352.
6. Carpenter JE, Blasier RB, Pellizzon GG. The effects of muscle fatigue on shoulder joint position sense. *Am J Sports Med.* 1998;26:262–265.
7. Pedersen J, Lönn J, Hellström F, Djupsjöbacka M, Johansson H. Localized muscle fatigue decreases the movement sense in the human shoulder. *Med Sci Sports Exerc.* 1999;31:1047–1052.
8. Marks R, Quinney HA. Effect of fatiguing maximal isokinetic quadriceps contractions on ability to estimate knee-position. *Percept Mot Skills.* 1993;77:1195–1202.
9. Sharpe MH, Miles TS. Position sense at the elbow after fatiguing contractions. *Exp Brain Res.* 1993;94:179–182.
10. Lattanzio PJ, Petrella RJ, Spourle JR, Fowler PJ. Effects of fatigue on knee proprioception. *Clin J Sports Med.* 1997;7:22–27.
11. Skinner HB, Wyatt MP, Hodgdon JA, Conard DW, Barrack RL. Effect of fatigue on joint position sense of the knee. *J Orthop Res.* 1986;4:112–118.
12. Lephart SM, Pincivero DM, Giraldo JL, Fu FH. The role of proprioception in the management and rehabilitation of athletic injuries. *Am J Sports Med.* 1997;25:130–137.
13. Scott SH, Loeb GE. The computation of position sense from spindles in mono- and multiarticular muscles. *J Neurosci.* 1994;14:7529–7540.
14. Barrack RL, Lund PJ, Skinner HB. Knee joint proprioception revisited. *J Sport Rehabil.* 1994;3:18–42.
15. Vangsness CT, Ennis M, Taylor JG, Atkinson R. Neural anatomy of the glenohumeral ligaments, labrum, and subacromial bursa. *Arthroscopy.* 1995;11:180–184.
16. Matthews PBC. Muscle afferents and kinaesthesia. *Br Med Bull.* 1977;33: 137–142.
17. McCloskey DI. Kinesthetic sensibility. *Physiol Rev.* 1978;58:763–820.
18. Guyton AC. *Textbook of Medical Physiology.* 6th ed. Philadelphia, PA: WB Saunders; 1981.
19. Djupsjöbacka M, Johannson H, Bergenheim M, Wenngren BI. Influences on the gamma-muscle spindle system from muscle afferents stimulated by increased intramuscular concentrations of bradykinin and 5-HT. *Neurosci Res.* 1995;22:325–333.
20. Djupsjöbacka M, Johannson H, Bergenheim M, Sjolander P. Influences on the gamma-muscle-spindle system from contralateral muscle afferents stimulated by KCl and lactic acid. *Neurosci Res.* 1995;21:301–309.
21. Djupsjöbacka J, Johannson H, Bergenheim M. Influences on the gamma-muscle-spindle system from muscle afferents stimulated by increased intramuscular concentrations of arachidonic acid. *Brain Res.* 1994;663: 293–302.
22. Powers SK, Howley ET. *Exercise Physiology: Theory and Application to Fitness and Performance.* 1st ed. Dubuque, IA: Wm. C. Brown; 1990:539.
23. Allegrucci M, Whitney SL, Lephart SM, Irrgang JJ, Fu FH. Shoulder kinesthesia in healthy unilateral athletes participating in upper extremity sports. *J Orthop Sports Phys Ther.* 1995;21:220–226.
24. Swanik CB, Henry TJ, Lephart SM. Chronic brachial plexopathies and upper extremity proprioception and strength. *J Athl Train.* 1996;31:119–124.
25. Lephart SM, Henry TJ. The physiological basis for open and closed kinetic chain rehabilitation for the upper extremity. *J Sport Rehabil.* 1996;5:71–87.
26. Tippett SR. Closed chain exercise. *Orthop Phys Ther Clinic N Am.* 1992;1:253–267.
27. Wilk KE, Arrigo C. Current concepts in the rehabilitation of the athletic shoulder. *J Orthop Sports Phys Ther.* 1993;18:365–378.
28. Swanik CB, Lephart SM, Giannantonio FP, Fu FH. Reestablishing proprioception and neuromuscular control in the ACL-injured athlete. *J Sport Rehabil.* 1997;6:182–206.

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Job Search and Employment-Related Issues in Athletic Training Education Programs

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Objective: To investigate the amount of classroom instruction appropriated for employment-related issues and how career service centers were used by students in National Athletic Trainers' Association (NATA)-approved/Commission on Accreditation of Allied Health Education Programs (CAAHEP)-accredited undergraduate athletic training curriculums.

Design and Setting: We developed a job placement survey and mailed it to subjects. The study was conducted through the School of Physical Education at West Virginia University.

Subjects: The subjects were all undergraduate athletic training curriculum directors employed in an NATA-approved or CAAHEP-accredited program.

Measurements: We developed a survey instrument based on our experiences with instructional and educational issues in athletic training. The survey instrument consisted of items that investigated the amount of classroom time and education devoted to different aspects of preparing athletic training students for the job market.

Results: A total of 74 surveys were returned, for an 88% return rate. Eighty-six percent of the curriculum directors spent an average of 116 minutes (mean = 116 ± 142.09; range, 5 to 780) instructing students about employment issues. Curriculum directors spent 63 minutes (mean = 63 ± 47.86; range, 10 to 270) instructing students on how to develop a résumé. Most curriculum directors (74%) spent time with students discussing how to prepare for an interview (mean = 51 ± 47.07 minutes; range, 1 to 270). Nearly all curriculum directors (97%) responded that students learned about recognizing allied health postgraduate career options other than athletic training. College or university career service centers were available to 96% of students, but only 53% sought instructional assistance from them. Curriculum directors spent an average of 38 ± 49.31 minutes (range, 15 to 120) discussing programs available at career service centers.

Conclusions: Athletic training curriculum directors were providing basic employment preparation skills to students. However, a wide variance existed for time allotted to employment-related issues. Additional research is needed to compare employment instructional methods with program success rates for job placement within athletic training.

Key Words: career services center, job application, job search, personnel management, vocational guidance

Graduating student athletic trainers seeking employment may undergo a frustrating ordeal. Students may ask how athletic training curriculums are preparing them for the job search, what comprehensive instructional job search techniques will be used, and what instructional formats will help to prepare them for the job search. Launching a job search can be a confusing, anxiety-producing act under the best of circumstances.[1] Therefore, having refined job search skills will improve the student's chances of success in securing employment in the competitive pool.

Student athletic trainers seeking employment opportunities while attending the National Athletic Trainers' Association (NATA) national convention know firsthand the competitive environment for available positions. According to the NATA Placement Service, there were more than 1000 candidates for 386 posted jobs during the 1996 national convention,[2] 674 candidates for 411 posted jobs during the 1997 convention,[3] and 1034 candidates for 584 posted jobs during the 1998 convention.[4] Therefore, students need educational preparation for the competitive job market before they begin a job search.

Figures from the Joint Review Committee on Educational Programs in Athletic Training[5] indicate that the number of undergraduate program graduates has increased over the past 4 years (Table 1). In addition, the NATA Board of Certification[6–10] has seen an increase in the number of undergraduate program candidates eligible for the certification examination (Table 2). These figures indicate that educational preparation for employment-related issues is necessary to meet the increased competition of students seeking postgraduate employment.

A review of the literature regarding athletic training employment issues revealed minimal results, but we did find information on topics such as employment opportunities, professionalism, salaries, and a saturated job market.[11–19] In professions such as emergency medicine, radiology, physical therapy, nursing, occupational therapy, and orthopaedics, discussions included career exploration and planning, employment market outlooks, and career success factors.[20–25] In business professions, the importance of networking, résumé formats, and

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Table 1. NATA-Approved/CAAHEP-Accredited Undergraduate Program Graduates[5]

Year	Number of Programs	Program Graduates
1997	87	953
1996	86	927
1995	85	857
1994	84	807
1993	84	727

Table 2. Undergraduate Program Candidates Eligible for the NATA Board of Certification Examination[6]

Year	Eligible Candidates
1997	883
1996	957
1995	857
1994	691
1993	652

using programs offered by career service centers in preparation for the job search process was addressed.[26–29] Thus, minimal empirical research is present within athletic training and other professions regarding employment-related issues.

The purpose of our study was to investigate the amount of classroom instruction appropriated for employment-related issues and how career service centers were used among NATA-approved/Commission on Accreditation of Allied Health Education Programs (CAAHEP)-accredited undergraduate athletic training curriculums.

METHODS

Subjects

The subjects were undergraduate athletic training curriculum directors in 1994–1995 who volunteered to participate in the study. Curriculum directors represented either an NATA-approved or a CAAHEP-accredited athletic training curriculum. There were no known risks posed to the subjects; therefore, a human subjects review was not conducted before the study. The survey instruments were not coded, thus ensuring subject confidentiality and anonymity.

Survey Instrument

We developed a job search preparation survey (Table 3) to investigate the amount of classroom instruction appropriated for employment-related issues (constructing a résumé, interview preparation, methods of locating employment opportunities, and various career options) and how career service centers were used by students in NATA-approved/CAAHEP-accredited athletic training curriculums.

The questions in our survey consisted of yes-no responses, short-answer questions, and scale rankings for importance of items. The 4 scale-ranked items ranged from least important (1) to most important (10). Short-answer questions asked the amount of time allotted to various employment-related issues, such as résumé design, interview preparation, and methods of locating employment opportunities. The survey focused on the amount of classroom instruction athletic training programs devoted to the different aspects of preparing for the job market. The survey instrument was designed for fact finding and compiling descriptive information; therefore, a pilot study was not conducted before the instrument was administered.

Table 3. Questions from the Job Search Preparation Survey

General
- Does your curriculum allocate classroom instruction toward job search and employment-related issues?

Résumé Design
- Does an instructor spend time teaching the importance of a résumé?
- What is the amount of class time allotted to résumé design?
- Are the appropriate formats of the résumé discussed?
- What is the preferred method for handling references?
- What is the preferred length of the résumé?

Interviewing Preparation
- Does an instructor take class time to discuss interview preparation?
- What is the amount of class time devoted to interview preparation?
- Are the following interview preparation items taught in class?
  - Appropriate dress for an interview
  - Asking questions of the interviewers
  - General conduct during the interview
  - Thank-you letters following an interview

Locating Employment Opportunities
- Does an instructor take class time to discuss methods of locating employment opportunities?
- What is the amount of class time devoted to locating athletic training employment opportunities?
- Are the following methods for locating employment opportunities discussed?
  - Professional journals
  - Faculty and staff
  - Networking
  - NATA Placement Vacancy Notices
  - Career service centers

Various Career Options
- Does an instructor take time discussing the various career options available to students?
- What is the amount of class time devoted to career options?
- Which of the following career option items are discussed?
  - High school athletic trainer
  - College/university athletic trainer
  - Graduate assistant athletic trainer
  - Clinical/industrial athletic trainer
  - Pursuing a terminal degree
  - Other allied health professions

Career Service Center
- Does your institution have a Career Service Center (CSC)?
- What is the amount of class time devoted to information on the CSC?
- Are personnel from the CSC utilized in the curriculum?
- What services are available at the CSC?
- What is the percentage of athletic training students who use the CSC?

Procedures

The survey instrument was mailed to 84 approved/accredited undergraduate athletic training program curriculum directors in July 1994. We mailed a follow-up reminder 2 months later, encouraging all curriculum directors to return the survey.

Statistical Analysis

Statistical analysis involved central tendency and descriptive statistics. We used the SPSS-X package (version 8; SPSS, Chicago, IL) for all statistical analyses.

RESULTS

A total of 74 curriculum directors completed and returned the survey instrument, for an 88% return rate.

Classroom Instruction

The curriculum directors allocated a range of 5 to 780 minutes for classroom instruction in job search preparation (Figure 1). The average amount of time spent on employment-related issues was 116 ± 142.09 minutes. Twenty-three percent of the curriculum directors stated they spent no time on employment-related skills instruction within the classroom.

Developing a Résumé

The mean amount of time curriculum directors spent instructing their students in the area of developing a résumé was 63 ± 47.86 minutes. The range was 10 to 270 minutes (Figure 2). In addition, 51% of the curriculum directors recommended including references on a résumé. Eighteen percent spent no time on résumé design.

Interview Preparation

Seventy-four percent of the surveyed curriculum directors instructed students on how to prepare for an interview. The

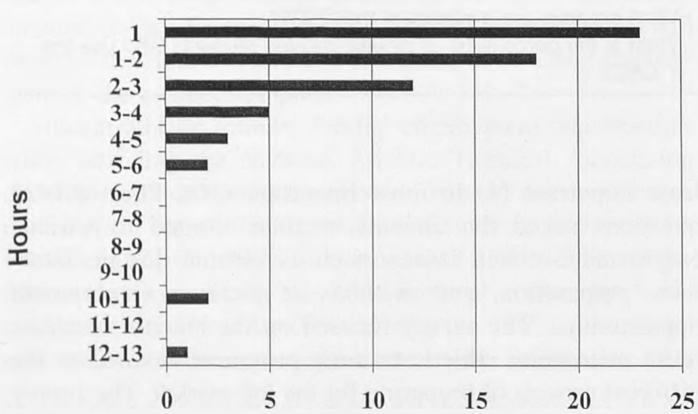

Figure 1. Classroom instruction time for job search preparation.

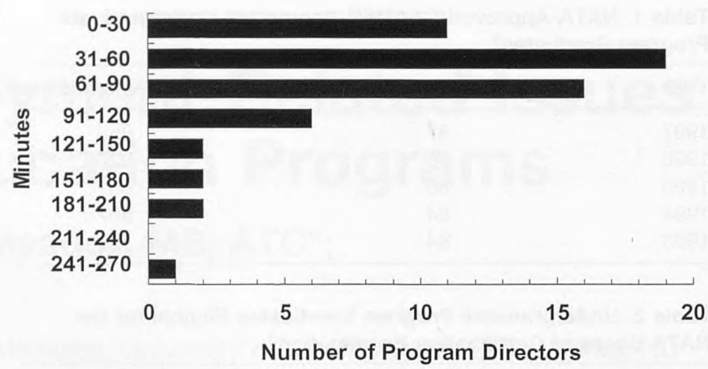

Figure 2. Time spent instructing in the development of a résumé.

mean amount of classroom time spent on this topic was 51 ± 47.07 minutes, with the range from 1 to 270 minutes. Also, 15% of the curriculum directors videotaped simulated interviews.

Locating Employment Opportunities

Ninety-two percent of the curriculum directors discussed methods of locating employment opportunities (Figures 3 and 4). Time allotted for locating employment opportunities ranged from 15 to 120 minutes (mean = 42 ± 49.31 minutes).

Career Options

Curriculum directors discussed a variety of career options with their students. More than 95% discussed high schools, colleges, universities, graduate assistantships, and clinical and corporate settings as potential career employment opportunities. More than 85% of the respondents discussed physical therapy as a career option. Other allied health options discussed were terminal degrees, physician assistant, medical school, occupational therapy, nursing, and podiatry.

Career Service Centers

Ninety-six percent of the institutions with NATA-approved/CAAHEP-accredited undergraduate athletic training curricu-

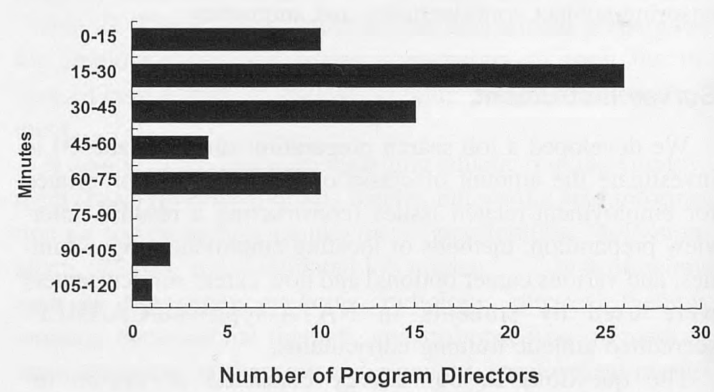

Figure 3. Time allotted for discussing methods of locating employment opportunities.

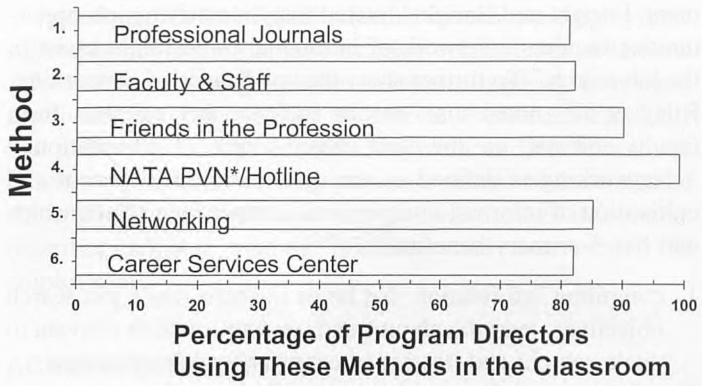

Figure 4. Methods of locating employment opportunities. *PVN, Placement Vacancy Notice.

lums also have career service center resources available on campus. A total of 54% of the curriculum directors had contacted the career service centers for some type of instructional assistance. The mean amount of time curriculum directors devoted to the career service center was 38 ± 49.31 minutes (range, 15 to 120 minutes). Half the curriculum directors estimated that their students do not use the career service centers despite efforts to inform and encourage them to do so.

DISCUSSION

Our study is the first to examine the extent to which employment-related issues are discussed within NATA-approved/CAAHEP-accredited undergraduate athletic training curriculums. Seventy-seven percent of curriculums provide basic exposure to job search skills. However, the topics, depth, time, and skill development vary greatly among the programs.

Our experiences in the placement room during past NATA conventions have shown that recent graduates were not well prepared for the job market. Incomplete résumés, poor interviewing skills, and lack of familiarity with the job search were some of the areas in which candidates exhibited insufficient preparation. However, it was often difficult to determine on the basis of preparedness whether a candidate was from a curriculum or an internship program.

Services provided by the NATA, such as the Placement Vacancy Notice and the job hotline, were the most popular methods used for seeking potential employment. In the past 5 years, the computer has become a major source of employment potential with the advent of the NATA web page and the computer listserve. However, at the time of data collection (1994–1995), our survey instrument did not include the computer listserve and the NATA web page as options for locating employment opportunities. Placement Room results from the 1998 national convention indicate that most athletic trainers use the computer for accessing information regarding potential employment opportunities.[4]

Curriculum directors may ask whether taking the time to teach job search skills in their programs will increase a student's chances of obtaining employment. Studies indicate that, if job searching skills are not addressed in curriculums, students will not think about career planning options.[30] Some institutions require business majors to take a career planning course, and the placement rate of these students 6 months after graduation in career-related jobs is greater than 90%.[30] Of equal importance is the fact that students should learn job search skills before they begin their job search.[31] Therefore, addressing job search skills within athletic training programs may increase the likelihood of students' gaining employment upon graduation.

We did not obtain demographic information such as educational background, years of professional experience, and administrative experience from the program directors who participated in the study. Perhaps those curriculum directors with backgrounds in administration were more likely to incorporate employment-related issues into their programs. Despite these limitations, the study provides useful information regarding the need to address employment-related issues within athletic training programs.

Résumé Design

Eighteen percent, or almost one fifth, of the curriculums did not spend any time on résumé design. However, the résumé is often the first impression the potential employer has of the candidate. A résumé may serve as a recruiter's tool for eliminating candidates or as a candidate's tool for gaining consideration.[29,32,33] Therefore, the résumé should have 1 goal: to help the student acquire an interview.[34–36] Résumé design is an important aspect of the job search, and we feel that athletic training curriculums should emphasize this process during a student's junior or senior year. Perhaps a senior seminar class or practicum is best suited to discussion of résumé design.[37]

Many student athletic trainers looking for their first job are in a precarious situation. Employers typically want to hire people with experience, which first-time job seekers seldom have.[38,39] Therefore, a number of alternatives are available to enhance their chances of gaining employment. Listing such skills as volunteer work, school activities, hobbies, club and professional memberships, internships, and part-time jobs provides further support of skills to a potential employee.[38] In addition, professional experience, honors, awards, and references need to be included.

Eisenberg[40] stated that "an effective résumé is an important marketing tool" and "the average résumé is initially scanned for only 20 to 30 seconds." Therefore, it is important for the student athletic trainer to include references with telephone numbers on the résumé, thereby allowing the potential employer to contact the references and perhaps increasing the student's chances for an interview.

Many excellent reference guides are available to assist students in designing a résumé.[32,34,38–56] These references offer practical tips on how to write an effective résumé and cover letter and provide hundreds of examples to peruse.

Interview Preparation

Twenty-six percent of the surveyed curriculums spend no time in the area of interview preparation. We were somewhat surprised by this figure and assumed that interview preparation, along with résumé design, would be discussed within all curriculums. Students who use the Placement Room during the NATA national convention often appear nervous and apprehensive. This may be associated with their lack of classroom preparation for the interview, as well as the anxiety they have developed in actual anticipation of the interview.

An interview is normally conducted before a job offer; therefore, the candidate should develop and refine interview skills before the interview. Enright and Enright[57] stated that, "in preparing for a job interview, the applicant should learn as much as possible about the potential employer, the job, and the interviewer."

Many services, books, videos, and seminars available to students offer suggestions on how to best prepare for an interview. Professionals recommend spending time preparing before the actual interview, and many references offer practical tips in preparing for an interview.[35,36,44,46,51,54,56–60] In addition, placement manuals offer tips on how to adequately prepare for an interview and encourage students to practice before the interview.[61]

After an interview, the student athletic trainer may want to send a follow-up thank-you letter. In fact, we found that 54% of curriculum directors discussed sending such a letter to potential employers after an interview. Sending a follow-up thank-you letter after an interview may separate an individual from other candidates applying for the same position. According to Adams (L. Adams, personal communication, May 14, 1998), the follow-up thank-you letter shows organization and courtesy, puts one's name in front of the employer once more, and allows one to expand on points from the interview. The follow-up thank-you letter should be written the same day as the interview and mailed immediately thereafter.

Methods of Locating Employment Opportunities

More than 85% of the curriculum directors recommended networking as a means of locating employment opportunities. Athletic trainers often use networking in capacities such as attending professional conferences (state, district, and national levels) and home and away athletic events and through the close interactions of the profession. Student athletic trainers, thus, are able to network with other athletic trainers through professional meetings and coverage of various home and away athletic events.

Athletic training is an altruistic profession by nature. The profession is a close-knit group of professionals dedicated not only to the health, care, and well-being of student-athletes, but also to the future status of their student athletic trainers. Therefore, when positions become available, a network of professional contacts is alerted in the hope of aiding student athletic trainers in securing graduate assistantships or employment. Enright and Enright[57] stated that "identifying job opportunities requires a network of individuals who might assist in the job search." To further show the importance of networking, Riley et al[62] noted that "results indicate that referrals from faculty and staff are the most valued source of information."

Networking is defined as the systematic development and cultivation of informal interpersonal contacts and relationships and has 3 primary benefits[28,54,58,63]:

1. compiling information that helps to focus one's job search objectives; learning about trends, events, or facts relevant to one's search; and hearing about existing job openings;
2. gaining as much exposure as possible in the job market; and
3. gathering more names and referrals so that one can continue to expand one's network, gain more information sources, receive more exposure, and obtain still more referrals.

Career service centers are mentioned as a resource for refining job search skills, but our research indicates that athletic training students underuse them. Only 24% of athletic training students use the services provided by career service centers. Data from the National Association of Colleges and Employers[64] indicate that, in 1997, 70% of graduating seniors used the career service center. Athletic training program directors should emphasize the benefits offered by career service centers in helping to better prepare students for the realities of the job market. Early interaction with career service centers allows students to see education goals as part of achieving employment goals and to begin linking the 2 areas.[65]

Career service centers can assist student athletic trainers in finding comprehensive information regarding possible employment. Resources available may include (depending on the college or university) an individual counseling session, participation in a videotaped simulated interview, seminars and workshops, job search courses, a career information library, and computerized career guidance and assessment.[34] Computerized career guidance and assessment consider students' occupations, values, interests, skills, and educational programs and assist them in identifying possible career options.[61] These services may be beneficial in assisting student athletic trainers to identify related allied health career opportunities.

CONCLUSIONS

Based on our findings, a wide discrepancy exists within athletic training curriculums on the amount of time allocated for employment-related issues. Basic preparations such as résumé design and interviewing skills play major roles in assisting student athletic trainers during the job hunt and should be a necessary component in all programs.

Athletic training curriculum directors should use this information to examine the amount of time allotted within their respective programs to employment issues. In addition, internship programs seeking CAAHEP accreditation should consider an emphasis on employment-related issues within their curriculums.

Future studies are needed to further investigate employment-related issues within athletic training curriculums. Additional information such as the number of letters, inquiries, or résumés candidates sent, the number of interviews for each candidate, the number of offers extended to each candidate, and the number of students securing positions should be investigated. Answers to these questions may provide further information regarding athletic training graduates and their search for employment.

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REFERENCES

1. National Association of College Employers. *Planning Job Choices: 1998 Four-Year College Edition.* Bethlehem, PA: National Association of Colleges and Employers; 1997:1–3.
2. Placement room statistics. Presented at: National Athletic Trainers' Association 47th Annual Meeting and Clinical Symposia; June 11–14, 1996; Orlando, FL.
3. Placement room statistics. Presented at: National Athletic Trainers' Association 48th Annual Meeting and Clinical Symposia; June 18–21, 1997; Salt Lake City, UT.
4. Placement room statistics. Presented at: National Athletic Trainers' Association 49th Annual Meeting and Clinical Symposia; June 17–20, 1998; Baltimore, MD.
5. *Joint Review Committee on Educational Programs in Athletic Training Annual Newsletter.* Terre Haute, IN; 1997.
6. National Athletic Trainers' Association Board of Certification. *Certification Update 1993.* Omaha, NE: National Athletic Trainers' Association Board of Certification; 1993.
7. National Athletic Trainers' Association Board of Certification. *Certification Update 1994.* Omaha, NE: National Athletic Trainers' Association Board of Certification; 1994.
8. National Athletic Trainers' Association Board of Certification. *Certification Update 1995.* Omaha, NE: National Athletic Trainers' Association Board of Certification; 1995.
9. National Athletic Trainers' Association Board of Certification. *Certification Update 1996.* Omaha, NE: National Athletic Trainers' Association Board of Certification; 1996.
10. National Athletic Trainers' Association Board of Certification. *Certification Update 1997.* Omaha, NE: National Athletic Trainers' Association Board of Certification; 1997.
11. AMA endorses athletic training as allied health profession. *NATA News.* February 1990:4.
12. Annual meeting attendance breaks records. *NATA News.* February 1990:1.
13. Goetze P. Are we a profession or a trade? *J Athl Train.* 1993;28:197.
14. Knight K. The sports medicine broker. *Athl Train, JNATA.* 1987;22:323–324.
15. Mishler B, Prentice WE. A national survey of employment opportunities for athletic trainers in the public schools. *Athl Train, JNATA.* 1986;21:215–219.
16. Mooney D, LeGear J. Athletic trainers better educated, NATA "getting younger," survey shows. *Athl Train, JNATA.* 1987;22:323.
17. Moss CL. Entry-level athletic trainer salaries. *J Athl Train.* 1992;29:205–207.
18. Ray R. A survey of Michigan school superintendents' knowledge of and attitudes toward athletic injuries, athletic trainers, and legal liability. *Athl Train, JNATA.* 1987;22:311–315.
19. Weidner T. It's up to ATCs to obtain higher salaries. *NATA News.* February 1991:4.
20. Kuhn GJ, Krome RL. Career planning and development for emergency medicine faculty. *J Emerg Med.* 1997;15:381–385.
21. Crewson PE, Sunshine JH, Schepps B. The situation of diagnostic radiology training programs and their graduates in 1997. *AJR Am J Roentgenol.* 1998;171:919–922.
22. Rozier CK, Raymond MJ, Goldstein MS, Hamilton BL. Gender and physical therapy career success factors. *Phys Ther.* 1998;78:690–704.
23. Duncan K. Student pre-entry experience and first year of employment. *J Contin Educ Nurs.* 1997;28:223–230.
24. Career exploration and development: a companion guide to the Occupational Therapy Roles document. *Am J Occup Ther.* 1994;48:844–851.
25. Evarts CM. Critical ingredients of an orthopaedic career. Presented at: Annual Meeting of the American Academy of Orthopaedic Surgeons; February 13, 1997; San Francisco, CA.
26. Noll CL. Collaborating with the career planning and placement center in the job search project. *Business Communication Q.* 1995;58:53–55.
27. Patterson V. Resume talk from recruiters. *J Career Plann Employment.* 1996;56:33–38.
28. Olson AA. Long-term networking: a strategy for career success. *Manage Rev.* 1994;83:33–35.
29. McNeilly KM, Barr TF. Convincing the recruiter: a comparison of resume formats. *J Educ Business.* 1997;72:359–363.
30. Brooks JE. Guide to developing a successful career course. *J Career Plann Employment.* 1995;55:29–33.
31. Kerr DL. Employment interviewing: a job search course. *Bulletin Assoc Business Commun.* 1992;55:5–7.
32. Adams RL. *The Adams Resume Almanac.* Holbrook, MA: Bob Adams; 1994:25–29.
33. Divita S. Résumé shifts power to employer. *Marketing News.* 1994;28:11.
34. Kalt NC. *CareerPower: A Blueprint for Getting the Job You Want.* Pound Ridge, NY: Career Power Books; 1996:13–30.
35. Stoodley M. *Information Interviewing: How to Tap Your Hidden Job Market.* 2nd ed. Chicago, IL: JG Ferguson Publishing; 1997:28–146.
36. Barkley N, Sandburg E. *Taking Charge of Your Career.* New York, NY: Workman Publishing; 1995:117–163.
37. Tsuchiya M, Meador R. 10 topics for "senior seminar." *NATA News.* Mar 1994:20–21.
38. Besson, T. *Résumés.* New York, NY: John Wiley Sons; 1996:177–196.
39. VGM Career Horizons. *Résumés for College Students and Recent Graduates.* Lincolnwood, IL: NTC Publishing Group; 1997:15–130.
40. Eisenberg JG. Guidelines for writing an effective resume. *J Am Diet Assoc.* 1986;86:1401–1403.
41. Parker Y. *The Résumé Catalog: 200 Damn Good Examples.* Berkeley, CA: Ten Speed Press; 1996:1–277.
42. Morin L. *Every Woman's Essential Job Hunting and Résumé Book.* Holbrook, MA: Bob Adams, Inc; 1994:13–215.
43. Kennedy JL. *Résumés for Dummies.* Foster City, CA: IDG Books Worldwide, Inc; 1996:111–225.
44. Messmer M. *Job Hunting for Dummies.* Foster City, CA: IDG Books Worldwide, Inc; 1995:57–313.
45. Asher D. *From College to Career: Entry-Level Résumés for Any Major.* Berkeley, CA: Ten Speed Press; 1992:25–174.
46. Studner PK. *Super Job Search: The Complete Manual for Job-Seekers and Career Changers.* 9th ed. Los Angeles, CA: Jamenair LTD; 1993:65–238.
47. Krannich RL, Krannich CR. *Dynamite Résumés: 101 Great Examples for Success.* Woodbridge, VA: Impact Publications; 1992:15–115.
48. Krannich RL, Banis WJ. *Résumés.* 5th ed. Manassas Park, VA: Impact Publications; 1992:20–196.
49. Anthony R, Roe G. *The Curriculum Vitae Handbook.* Iowa City, IA: Rudi Publishing; 1994:17–108.
50. Noble D. *Gallery of Best Résumés: A Collection of Quality Resumes by Professional Résumé Writers.* Indianapolis, IN: JIST Works, Inc; 1994:8–349.
51. Chapman EN. *Be True to Your Future: Practical Steps to Career Success and Personal Fulfillment.* Los Altos, CA: Crisp Publications; 1988:91–144.

52. Jackson AL. *How to Prepare Your Curriculum Vitae.* Lincolnwood, IL: NTC Publishing Group; 1994:17–107.
53. McDaniels C. *Developing a Professional Vita or Résumé.* 3rd ed. Chicago, IL: JG Ferguson Publishing; 1997:99–128.
54. Morgan BJ, Palmisano JM. *Therapists and Allied Health Professions Career Directory.* Detroit, MI: Visible Ink Press; 1993:99–168.
55. Kennedy JL, Morrow TJ. *Electronic Résumé Revolution: Creating a Winning Résumé for the New World of Job Seeking.* 2nd ed. New York, NY: John Wiley & Sons; 1995:69–205.
56. Bender LH. Résumé writing and interviewing skills for getting the job you want. *Orthop Nurs.* 1997;16:9–15.
57. Enright SM, Enright SJ. Tips for making the job search productive and enjoyable. *Am J Hosp Pharm.* 1984;41:924–927.
58. Richardson BG. *Jobsmarts for Twentysomethings.* New York, NY: Random House; 1995:122–138.
59. Yate M. *Knock 'Em Dead.* 11th ed. Holbrook, MA: Adams Media Corporation; 1998:115–235.
60. Bolles RN. *What Color is Your Parachute?* 25th ed. Berkeley, CA: Ten Speed Press; 1997:167–222.
61. *Career Services Center at West Virginia University: Placement Manual.* Morgantown, WV: Cass Recruitment Media; 1998:14.
62. Riley K, Myers W, Schneeweiss R. Recruiting physicians to rural practice: suggestions for success. *West J Med.* 1991;155:500–504.
63. Krannich RL, Krannich CR. *Network Your Way to Job and Career Success: The Complete Guide to Creating New Opportunities.* Manassas, VA: Impact Publications; 1989:11–116.
64. National Association of Colleges and Employers. Snapshot of the profession. *Career Plann Employment.* 1998;32:55.
65. Farris MT, Maes JD. Tips on reviewing students' résumés. *J Educ Business.* 1996;71:368–371.

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Obsessive-Compulsive Disorder and Anorexia Nervosa in a High School Athlete: A Case Report

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Objective: To describe the case of a basketball and track athlete who presented with both anorexia nervosa and obsessive-compulsive disorder (OCD).

Background: OCD is a psychiatric condition known to appear with significant frequency among those with anorexia. Although treatable with drug and behavioral therapy, it must be specifically sought because some of its symptoms are similar to those of anorexia nervosa.

Differential Diagnosis: Obsessive-compulsive disorder, anxiety disorder.

Treatment: Behavioral therapy involves exposure to the obsessive fears without allowing the patient to ritualize. This is best used in combination with drugs that selectively block the reuptake of serotonin in the brain.

Uniqueness: Anorexia nervosa is notoriously difficult to treat. In our patient, anorexic symptoms all but disappeared along with the OCD in a matter of weeks, once treatment of the OCD began. Lengthy treatment for anorexia alone had been unsuccessful.

Conclusions: OCD occurs frequently in patients with anorexia, and successful treatment requires that both conditions be specifically identified and managed. Athletic trainers may be the first to recognize key signs and symptoms of this illness; by referring the individual for psychiatric evaluation, they can be instrumental in helping the patient to obtain appropriate treatment.

Key Words: anxiety disorder, selective serotonin reuptake inhibitor, SSRI, obsessions, compulsions, eating disorder

Psychiatric disorders do not readily come to mind when discussing the typical work of athletic trainers, but when athletes' health and performance are affected, athletic trainers become involved. Anorexia nervosa is a psychiatric condition that athletic trainers have become familiar with. As a result, prevention and management programs for this condition have been instituted in many athletic departments. Obsessive-compulsive disorder (OCD) is another psychiatric condition in which athletic trainers can play a helpful role. Research in the past decade has shown several aspects of OCD that make it relevant to athletic trainers: in particular is the significantly high rate of comorbidity between OCD and anorexia nervosa. Additionally, its typical age of onset corresponds to the population group that athletic trainers commonly work with, and its prevalence is high enough that athletic trainers may very well be working among its sufferers.

We present the case of a severely anorexic athlete who also had OCD. Her OCD was not recognized while she was under lengthy treatment for anorexia nervosa that progressed to serious starvation. Dramatic recovery of both the OCD and the anorexia nervosa followed the recognition and subsequent treatment of her OCD. We provide background information on the lesser-known condition of OCD, along with current treatment methods and a discussion of the relationship of the 2 conditions.

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CASE REPORT

A 14-year-old high school female began her freshman year weighing 45.9 kg (101 lb) and with a height of 165 cm (65 in). On the physical examination required for all students before entering high school, she was found to be normal and healthy. She participated in basketball and track. However, she had begun to exercise compulsively outside of athletics and to restrict her dietary intake severely. Weight loss became apparent. When her weight dropped to 42.3 kg (93 lb) shortly after the school year ended, her family physician diagnosed anorexia nervosa. Treatment included extensive family and individual psychotherapy and counseling with a dietitian who specialized in eating disorders. These interventions were of moderate benefit in that, at best, the patient maintained her weight in the 38- to 40-kg (mid to upper 80-lb) range while she continued to restrict her dietary intake and to exercise compulsively. At the age of 15, her weight dropped to 38.2 kg (84 lb). At this time, bradycardia, fatigue, and weakness were noted. A series of hospitalizations was begun, including nasogastric tube feedings that continued for some time as an outpatient. Despite continued extensive cognitive behavioral treatment and the exploration of dynamic issues in her life, her weight remained below 43 kg (95 lb), which was less than 75% of her ideal body weight. Her behaviors of compulsive exercising and dietary restriction continued, including self-removal of the nasogastric tube to avoid the feedings.

Approximately 18 months after initially seeking treatment, the patient was referred to another psychiatrist, who found that, in addition to her eating disorder, which had begun at age 14, she also exhibited clear signs of OCD. Questioning revealed that she had begun having obsessions and compulsions at the age of 8 years. She had contamination obsessions involving washing rituals and counting rituals with "good" and "bad" numbers. Some of the things she counted were lines on the sidewalk, stair steps, and basketball dribbles. Some of her rituals were tied to obsessions that she had to perform to protect her family from harm. In addition, she had numerous compulsive rituals centered on her eating. She had extensive rituals for preparing her food, arranging her food on the plate and table, and eating her food. She also had some body image issues and felt she had to wear certain clothes.

Subsequently, the patient was started on Prozac (Dista Products, Indianapolis, IN) 20 mg per day. Cognitive behavioral therapy targeting OCD rather than anorexia was initiated. Within 10 weeks of the start of treatment, both her OCD and anorexia nervosa had improved dramatically. OCD symptomatology was reduced by more than 80%, and her weight increased to 47.7 kg (105 lb). At this point, she was healthy enough to return to school and to basketball. Six months after initiating OCD treatment, her weight had increased to 54.5 kg (120 lb), her anorexia was essentially in remission, and OCD symptomatology was reduced by more than 90%. She was very active in school and doing well academically and socially. She competed in cross-country and ran distance events in track her junior and senior years without excessive exercising. She was not overly concerned with her performance or her weight, but participated for the enjoyment of it. She demonstrated a winsome and pleasant personality that was not seen during her illness. Follow-up in 2 years revealed that the improvements had persisted, with the anorexia still in remission and her weight ranging from 52.3 to 54.5 kg (115 to 120 lb). She continued to take Prozac 10 mg per day. OCD symptoms flared up episodically, particularly when she was under stress; however, these were successfully managed with cognitive behavioral techniques, and essentially she functioned very well.

DISCUSSION

Background Information

During the 1980s, OCD gained the attention of researchers and the popular media. Research during this time revealed much about the nature and successful treatment of OCD. Concurrently, there was a marked increase in the diagnosis of OCD,[1] which continues to be an area of active interest and significant research in the psychiatric field.

A person with OCD should not be confused with the person we lightly refer to as "compulsive." Many healthy people sometimes feel "compelled" to do things or experience incidents of obtrusive thoughts. Athletic trainers frequently work among athletes who seem to be compulsive about their workouts or who hold to superstitions that they believe affect their performance. These traits are the subjects of a separate area of research.[2] An individual with OCD is far more controlled by thoughts and disordered in behavior.

OCD patients have a pattern of distressing and senseless thoughts or ideas—obsessions—that repeatedly well up in their minds. To quell the distressing thoughts, specific patterns of odd behaviors—compulsions—develop. The compulsions become carefully performed rituals that trap the person, who fears failing to perform them perfectly. They vary widely, often change over time, and are sometimes quite bizarre.[3–5] To fit the diagnostic criteria for OCD, these patterns must consume significant time, be very distressing to the individual, and interfere with daily life.[4,6–8]

OCD patients typically recognize that their thoughts and behaviors are senseless. However, this knowledge does not allow patients to escape the compulsions, although some are able to resist the behaviors for a time. If the disorder progresses, the compulsions consume more time and energy, and daily life is interfered with to an increasing extent.[4,6,7]

OCD can express itself in many ways. Some of the most common compulsions are arranging objects, counting, washing, and "checking."[3,4,7–12] "Checking" refers to repeatedly making sure that doors are locked, that the stove is off, etc. Previously, it was believed that attitudes learned in childhood caused these behaviors, but current evidence clearly indicates a neurobiologic link with the disorder.[6,7,13] A genetic origin is among the possible causes, as indicated by studies that have found a significantly higher incidence of OCD or obsessive-compulsive behavior in parents of OCD children than in comparison populations[11,14] and a higher concordance rate among monozygotic twins than dizygotic twins.[8]

Prevalence and Age of Onset

Although once believed to be rare, research now indicates that the lifetime rate of prevalence of OCD is as high as 3% in the general population.[6,7,15–18] Valleni-Basile et al[12] found a similar rate among adolescents. We found no studies that attempted to determine the prevalence of OCD among athletes. The onset of the disorder is nearly always in adolescence or young adulthood, but symptoms can appear in childhood.[6,11,16,17,19] The course of OCD is chronic; symptoms may wax and wane, but patients rarely become asymptomatic.[20,21] Treatment is directed at controlling the symptoms, not at curing the disease.

Treatment

OCD is treated with behavioral therapy and medication. A combination of the 2 may be the most effective.[4–6,15,21–23] Drugs that have demonstrated their effectiveness and are approved for OCD treatment in the United States are fluoxetine (Prozac),[24] clomipramine (Anafranil; Novartis Consumer Health, Inc, Summit, NJ),[15,25–27] fluvoxamine (Luvox; Solvay Pharmaceuticals, Inc, Marietta, GA),[22,28] and sertraline hydrochloride (Zoloft; Pfizer, Inc, New York, NY).[21,29,30] They act to block the reuptake of the neurotransmitter serotonin at axon terminals in the brain and are commonly referred to as selective serotonin reuptake inhibitors, or SSRIs. SSRIs are prescribed for a number of psychiatric disorders, including eating disorders. Of significant note is the fact that the typical effective dose of these drugs when used to treat OCD is greater than the effective dose typically prescribed for depression, including depression associated with anorexia. Another difference is that the improvement in OCD symptoms may be more gradual than the improvement in depression.[21] Behavioral therapy involves graduated exposures to the source of obsessive fears while preventing the patient from ritualizing. A tendency for patients to maintain some degree of improvement after behavioral therapy has been found, while those treated with drugs alone tend to relapse when medication is discontinued.[7,15]

Relationship to Anorexia Nervosa

The nature of the relationship of OCD to anorexia is not yet established. In a 1990 review, Holden[19] concluded that epidemiologic evidence did not show a strong relationship but noted similarities between the 2 conditions. On the other hand, in 1994, McElroy et al[31] suggested placing anorexia in a spectrum of disorders that have many similarities with OCD and may, therefore, be related to OCD. Certain neurochemical similarities between eating disorders and OCD have been demonstrated,[32] which may bolster the latter view.

A number of disorders are known to frequently appear comorbidly with OCD. While anorexia is not believed to be among the most common comorbid disorders of OCD, its overrepresentation in the past history of OCD patients has been repeatedly documented.[33–37] Additionally, Pigott et al[38] found that OCD patients on average scored higher than healthy subjects on all 8 subscales of the Eating Disorder Inventory.[38] Rubenstein et al[35] found that 17.7% of OCD patients met subthreshold criteria for either anorexia or bulimia.

Looking from the standpoint of patients with diagnosed anorexia, similar relationships have been found. Kaye et al,[39] Halmi et al,[40] and Thiel et al[41] found that OCD occurred among patients with anorexia with significantly greater frequency than among the normal population. Thomsen[42] found that 4 of 19 females with eating disorders had a past history of OCD.

A number of thought and behavioral similarities exist between anorexia and OCD. Ritualistic and compulsive behaviors and obsessions are some of the identifying characteristics shared by anorexia and OCD.[14] Among patients with anorexia, these are related only to food and thinness. If OCD is also present, obsessions and compulsions are not restricted to anorexic patterns.[4] Secretiveness, or attempting to hide certain behaviors, and feelings of shame and guilt can be common to both. Specific diagnostic tools help distinguish and identify each disorder. The Yale-Brown Obsessive-Compulsive scale and the Eating Disorder Inventory are standardized tools that provide an objective reference for diagnosis of each disorder when administered by professionals trained in their use.

CONCLUSIONS

Since it has been established that patients with anorexia have a significantly higher incidence of OCD than the general population, a routine investigation for OCD when anorexia is suspected or diagnosed is appropriate. Because OCD shares traits with anorexia, and because athletes are often considered "compulsive," a complete investigation using objective diagnostic tools is important. Among athletes, the areas of life apart from athletics and unrelated to eating must not be overlooked. Further research into OCD may clarify the reason for the high incidence of OCD among those with anorexia, resulting in earlier intervention and better treatment.

In addition, since the incidence of OCD in the general population is as high as 3% and the age of onset is overwhelmingly the adolescent and young adult age groups with whom athletic trainers in the traditional settings work, athletic trainers should be aware of basic OCD signs and symptoms. This awareness may permit an important diagnosis for any athlete, anorexic or not. The close and trusting relationship many athletic trainers have with their athletes may put them in a position to discover obsessions or compulsions that are inordinate. Simply asking the individual if he or she has disturbing, repetitive thoughts may result in the athlete's bringing forth information crucial to a successful diagnosis and treatment. Providing information and referral to a professional trained in psychiatric diagnosis whenever OCD or any psychiatric condition is suspected falls within the athletic trainer's general duties. Athletic trainers have often been key to early medical intervention for anorexic athletes. OCD is another difficult and tenacious psychiatric illness in which athletic trainers can play a key role by helping those who are suffering to obtain effective treatment.

REFERENCES

1. Stoll AL, Tohen M, Baldessarini RJ. Increasing frequency of the diagnosis of obsessive-compulsive disorder. *Am J Psychiatry.* 1992;149:638–640.
2. Hauck ER, Blumenthal JA. Obsessive and compulsive traits in athletes. *Sports Med.* 1992;14:215–227.
3. Rettew DC, Swedo SE, Leonard HL, Lenane MC, Rapoport JL. Obsessions and compulsions across time in 79 children and adolescents with obsessive-compulsive disorder. *J Am Acad Child Adolesc Psychiatry.* 1992;31:1050–1056.
4. Dickey M. *Anxiety Disorders.* Rockville, MD: National Institute of Mental Health; 1994:15–19.
5. Yaryura-Tibias JA, Neziroglu FA, Kaplan S. Self-mutilation, anorexia, and dysmenorrhea in obsessive-compulsive disorder. *Int J Eat Disord.* 1995;17:33–38.
6. Hendrix ML. *Obsessive-Compulsive Disorder.* Washington, DC: National Institute of Mental Health; 1991.

7. Sturgis ET. Obsessive-compulsive disorder. In: Sutker PB, Adams HE, eds. *Comprehensive Handbook of Psychopathology*. 2nd ed. New York, NY: Plenum Press; 1993:129–144.
8. *Diagnostic and Statistical Manual of Mental Disorders*. 4th ed. Washington, DC: American Psychiatric Association; 1994:417–423.
9. Allsopp M, Verduyn C. Adolescents with obsessive-compulsive disorder: a case note review of consecutive patients referred to a provincial regional adolescent psychiatry unit. *J Adolesc.* 1990;13:157–169.
10. Leonard HL, Goldberger EL, Rapoport JL, Cheslow DL, Swedo SE. Childhood rituals: normal development or obsessive-compulsive symptoms? *J Am Acad Child Adolesc Psychiatry.* 1990;29:17–23.
11. Riddle MA, Scahill L, King R, et al. Obsessive-compulsive disorder in children and adolescents: phenomenology and family history. *J Am Acad Child Adolesc Psychiatry.* 1990;29:766–772.
12. Valleni-Basile LA, Garrison CZ, Jackson KL, et al. Frequency of obsessive-compulsive disorder in community sample of young adolescents. *J Am Acad Child Adolesc Psychiatry.* 1994;33:782–791.
13. Black DW, Noyes R Jr, Goldstein RB, Blum N. A family study of obsessive-compulsive disorder. *Arch Gen Psychiatry.* 1992;49:362–368.
14. Thomsen PH. Obsessive-compulsive disorder in children and adolescents: a 6–22 year follow-up study: clinical descriptions of the course and continuity of obssessive-compulsive symptomatology. *Eur Child Adolesc Psychiatry.* 1994;3:82–96.
15. Feinberg M. Clomipramine for obsessive-compulsive disorder. *Am Fam Physician.* 1991;43:1735–1738.
16. Hantouche EG, Bourgeois M. Obsessive-compulsive disorders versus obsessive-compulsive syndromes: comparative study of two surveys of the general population and of psychiatric consultants. *Ann Med Psychol (Paris).* 1995;153:314–325.
17. Kolada JL, Bland RC, Newman SC. Obsessive-compulsive disorder. *Acta Psychiatr Scand.* 1994;89(suppl):24–35.
18. Robins LN, Helzer JE, Weissman MM, et al. Lifetime prevalence of specific psychiatric disorders in three sites. *Arch Gen Psychiatry.* 1984; 41:949–955.
19. Holden NL. Is anorexia nervosa an obsessive-compulsive disorder? *Br J Psychiatry.* 1990;157:1–5.
20. DeVeaugh-Geiss J. Pharmacologic therapy of obsessive compulsive disorder. *Adv Pharmacol.* 1994;30:35–52.
21. Pary R, Lippmann S, Tobias CR. Obsessive-compulsive disorder: how to free patients from intrusive thoughts and rituals. *Postgrad Med.* 1994;96: 119–125.
22. Greist JH. An integrated approach to treatment of obsessive compulsive disorder. *J Clin Psychiatry.* 1992;53(suppl):38–41.
23. Abel JL. Exposure with response prevention and serotonergic antidepressants in the treatment of obsessive compulsive disorder: a review and implications for interdisciplinary treatment. *Behav Res Ther.* 1993;31: 463–478.
24. Wood A, Tollefson GD, Birkett M. Pharmacotherapy of obsessive-compulsive disorder experience with fluoxetine. *Int Clin Psychopharmacol.* 1993;8:301–306.
25. Trimble MR. Worldwide use of clomipramine. *J Clin Psychiatry.* 1990; 51(suppl):51–54.
26. Jenike MA, Baer L, Summergrad P, Weilburg JB, Holland A, Seymour R. Obsessive-compulsive disorder: a double-blind, placebo-controlled trial of clomipramine in 27 patients. *Am J Psychiatry.* 1989;146:1328–1330.
27. Piacentini J, Jaffer M, Gitow A, et al. Psychopharmacologic treatment of child and adolescent obsessive compulsive disorder. *Psychiatr Clin North Am.* 1992;15:87–107.
28. Montgomery SA, Manceaux A. Fluvoxamine in the treatment of obsessive compulsive disorder. *Int Clin Psychopharmacol.* 1992;1(suppl):5–9.
29. Dominguez RA. Serotonergic antidepressants and their efficacy in obsessive compulsive disorder. *J Clin Psychiatry.* 1992;53(suppl):56–59.
30. Chouinard G. Sertraline in the treatment of obsessive-compulsive disorder: two double-blind, placebo-controlled studies. *Int Clin Psychopharmacol.* 1992;2(suppl):37–41.
31. McElroy SL, Phillips KA, Keck PE Jr. Obsessive compulsive spectrum disorder. *J Clin Psychiatry.* 1994;55(suppl):33–53.
32. Jarry JL, Vaccarino FJ. Eating disorder and obsessive-compulsive disorder: neurochemical and phenomenological commonalities. *J Psychiatry Neurosci.* 1996;21:36–48.
33. Fahy TA, Osacar A, Marks I. History of eating disorders in female patients with obsessive-compulsive disorder. *Int J Eat Disord.* 1993;14:439–443.
34. Noshirvani HF, Kasvikis Y, Marks IM, Tsakiris F, Monteiro WO. Gender-divergent aetiological factors in obsessive-compulsive disorder. *Br J Psychiatry.* 1991;158:260–263.
35. Rubenstein CS, Pigott TA, L'Heureux F, Hill JL, Murphy DL. A preliminary investigation of the lifetime prevalence of anorexia and bulimia nervosa in patients with obsessive compulsive disorder. *Am J Psychiatry.* 1992;53:309–314.
36. Tamburrino MB, Kaufman R, Hertzer J. Eating disorder history in women with obsessive compulsive disorder. *J Am Med Wom Assoc.* 1994;49:24–26.
37. Zribi S, Chambon O, Cottraux J. Anorexia nervosa: a frequent antecedent of obsessive compulsive disorders. *Encephale.* 1989;15:355–358.
38. Pigott TA, Altemus M, Rubenstein CS, et al. Symptoms of eating disorders in patients with obsessive-compulsive disorder. *Am J Psychiatry.* 1991;148:1552–1557.
39. Kaye WH, Weltizin TE, Hsu LG, Bulik C. Patients with anorexia nervosa have elevated scores on the Yale-Brown obsessive-compulsive scale. *Int J Eat Disord.* 1992;12:57–62.
40. Halmi KA, Eckert E, Marchi P, Sampugnaro V, Apple R, Cohen J. Comorbidity of psychiatric diagnoses in anorexia nervosa. *Arch Gen Psychiatry.* 1991;48:712–718.
41. Thiel A, Ohlmeier M, Jacoby GE, Schussler G. Compulsive symptoms in anorexia and bulimia nervosa. *Psychother Psychosom Med Psychol.* 1995;45:8–15.
42. Thomsen PH. Obsessive-compulsive disorder in children and adolescents: a study of parental psychopathology and precipitating events in 20 consecutive Danish cases. *Psychopathology.* 1995;28:161–167.

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A Unique Finger Injury in a Professional Hockey Player: A Case Report

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Objective: To present an uncommon athletic soft tissue wound and its proper management.

Background: Soft tissue wounds are common in athletic competition. However, the subcategory of puncture wounds due to impalement by foreign bodies is quite rare. Although initial observation of a puncture wound may show minimal injury and blood loss, one must be concerned about damage to underlying structures and risk of infection.

Differential Diagnosis: Fracture, tendon injury, neurovascular compromise, soft tissue injury.

Treatment: When dealing with an impaled foreign object, it is vital to stabilize the injured area and leave the object in place. Prompt evaluation and removal by a physician is necessary. Also, the risk of infection is significant after a puncture wound, and prophylactic antibiotics should be considered.

Uniqueness: Impalement by foreign objects is rare in sports, particularly hockey. Incorrect management of athletes with this injury could lead to additional morbidity.

Conclusions: Although puncture wounds and impalement by foreign objects are not frequently seen in athletes, proper recognition, treatment, and management are essential to avoid complications and loss of function.

Key Words: puncture wounds, impalement by foreign objects, impalement by foreign bodies

Soft tissue wounds in professional hockey are common, with lacerations and incisions to the face being the most prevalent.[1] However, an extensive literature search showed that puncture wounds due to impalement by foreign bodies are rare in the athlete, although they remain a common problem in the clinic.[2] Because injuries from impalement by foreign objects can penetrate deeply, damage to underlying structures is possible, and early recognition is important. The following case study details an unusual puncture wound in a professional hockey player, an injury not previously documented in the literature.

CASE REPORT

The subject was a 33-year-old male professional hockey player (height = 190 cm; weight = 102.06 kg). The athlete presented to the athletic trainers during a pregame skate, complaining of intense pain in his left hand. Upon observation, we saw a piece of wood protruding from the palmar surface of the index finger through his hockey glove. The athlete stated that this occurred as he slid his hand down the shaft of his hockey stick. The involved stick was made of wood with a fiberglass coating. The hockey glove had a leather palm and was in otherwise good condition.

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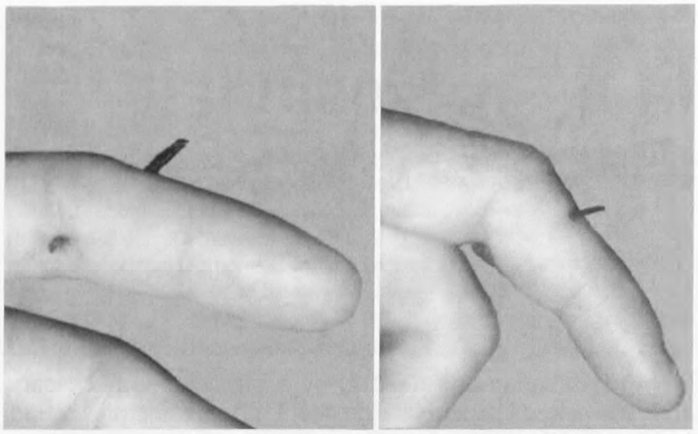
Initial evaluation of the injury was difficult because we were unable to remove the glove. A portion of the wood was trimmed, and the athlete was able to slip his hand out of the glove. At this time it was obvious that the injury involved not simply a large sliver, but impalement by a foreign object. The 4-mm-diameter fragment of wood had entered the palmar side of the right index finger and exited the dorsal aspect slightly distal and lateral to the proximal interphalangeal joint (Figure). There was no bleeding with this injury, and examination showed normal sensation and capillary refill. Arrangements were made to meet the team hand surgeon in a local emergency room, and an athletic trainer transported the athlete there.

After examination, the surgeon determined that there was no neurovascular compromise and that removal of the impaled foreign object could continue. The entrance and exit wounds, as well as the dorsal aspect of the foreign object, were first cleansed with Betadine (The Purdue Frederick Co, Norwalk, CT). The surgeon performed a digital block using lidocaine for pain control during extraction. The piece of wood was removed with forceps from the dorsal surface. After removal of the foreign object, the athlete exhibited full range of motion of the involved index finger, and reexamination showed normal capillary refill. The entrance and exit wounds did not require sutures for closure, and they were cleaned and dressed. Because of the high risk of infection associated with this type of injury, the athlete was started on prophylactic antibiotics. The athlete also received a tetanus immunoglobulin injection because his previous tetanus booster had been 12 years earlier. He returned to play in a game within 8 hours. The athlete reported only minimal discomfort and suffered no complications as a result of this injury.



Impaled finger before removal of the foreign body. Approximately 5 cm of the foreign body has been trimmed.

DISCUSSION

Although rare in the athletic arena, puncture wounds and foreign bodies in the hand are common and can present with several complications.[2–8] Prompt recognition and treatment of puncture wounds and impalement by foreign objects are important for a successful recovery. The initial examination by an athletic trainer should include observation for bleeding, deformity of bone or joint, and adequate perfusion of distal structures and evaluation of sensation. Other concerns are secondary injuries, underlying medical conditions, and, in severe instances, traumatic shock. During the initial examination and treatment, the foreign object should be left in place, although it may be necessary to shorten the object for further evaluation or transport. Bleeding should be controlled with direct pressure and elevation, and the athlete should be immediately brought to an emergency room for treatment by a physician.[1,9,10]

Initial detection of the foreign body is the cornerstone of treatment. In this particular case, the foreign body was obvious upon observation (Figure). However, many foreign bodies are completely within the soft tissue and may at first appear only as a puncture. Anderson et al[11] found that 40% of retained foreign bodies were not detected upon initial examination by a physician. Plain x-rays, commonly used for further investigation, detect only 15% of wood foreign bodies.[5] Wood is radiolucent and, therefore, is difficult to detect. Previously, computed tomography and magnetic resonance imaging were performed if all other tests were negative,[3,4,6] but, more recently, ultrasound has been used successfully in detecting and localizing radiolucent foreign bodies. Bonatz et al[6] found that ultrasonography had 95% sensitivity and 89% specificity in patients with negative radiographs who were suspected to have foreign bodies in the hand.

In this patient, no radiologic studies were performed. This was due to the location of the foreign object impalement radial to the joint and also the suspected complete removal of the object. As stated earlier, the hockey stick was wood with a fiberglass coating, which was helpful in maintaining the wood and not allowing it to splinter further during removal.

After detecting a foreign body, it is also important to evaluate for neurovascular intactness, which may be impaired by the penetrating nature of these injuries. The hand surgeon tested circulation by performing a digital Allen test. This is done by simultaneously occluding the palmar and dorsal digital arteries of the index finger manually. After temporarily restricting blood flow, pressure from 1 side is released, and blood flow to the fingertip is observed. The test is then repeated on the opposing side of the finger. However, even in instances of focal compromised arterial flow, collateral circulation can compensate, adequately perfusing the distal structures. The athlete in this case had normal circulation with no blood loss and normal sensation. Additionally, range of motion should always be evaluated, especially if the foreign body is near a joint or suspected of being lodged in a tendon.

The standard principles of wound management apply, with some exceptions, to the removal of the foreign object.[12] If the foreign object is small or easy to remove, a local or regional anesthetic can be used. If the object is larger or if wound exploration is necessary, general anesthesia in the operating room may be used. One end of the foreign body may be trimmed or shortened before removal to help prevent additional contamination and also decrease soft tissue irritation. Before removing the object, the wound and surrounding area (including the foreign body) are cleansed. If bleeding is present, a tourniquet provides optimal visualization during removal. At this point, the object is ready for extraction. In this patient, the foreign body was removed through the exit wound, although different techniques can be used, depending on the material. After removal of the object, the wound is irrigated and debrided thoroughly. Vascular and tendon integrity should be checked after extraction, but sensory examination will be inaccurate secondary to anesthesia and should, therefore, be repeated after the local anesthetic has worn off. Puncture wounds are usually left open, and a sterile dressing is applied. However, larger wounds or extended incisions may require loose closure with nonabsorbable sutures. A 5-day course of antibiotics is started immediately.[12,13] A tetanus immunoglobulin injection should be given if the athlete's previous tetanus booster is more than 10 years old.[14] Lastly, the athlete should be reevaluated within 48 to 72 hours by the physician and daily by the athletic trainer to inspect the wound for any signs of infection.

Failure to treat and manage these injuries properly can lead to additional morbidity. Therefore, it is important to recognize complications that may arise after initial management. Because wood is an immunogenic substance, the body will reject the foreign object, causing soft tissue inflammation and possible infection. Thus, removal of the object should be as complete as possible.[5] The inflammation associated with foreign body retention can mimic infective arthritis, rheumatoid arthritis, pyogenic osteomyelitis, and soft tissue tumor.[8] Wendt and Ackley[2] have also documented that a previously asymptomatic foreign body can lead to complications such as artery erosion, thromboemboli, and digital ischemia. The risks of wound infection and tetanus are addressed according to standard principles of wound management.

CONCLUSIONS

Although many complications can arise from impalement by a foreign object, this patient had no adverse effects. The prompt and correct recognition, treatment, and management allowed the athlete to return to participation without additional morbidity. It is the athletic trainer's responsibility to manage this wound properly and to ensure that the physician evaluates the athlete. While the incidence of impaled foreign objects in the athletic population is rare, all athletic trainers should be familiar with the correct medical care of this injury.

REFERENCES

1. Arnheim D. *Modern Principles of Athletic Training.* 7th ed. St. Louis, MO: Times Mirror/Mosby College Publishing; 1989:13.
2. Wendt JR, Ackley SM. Vascular complications of a foreign body in the hand of an asymptomatic patient. *Ann Plast Surg.* 1995;34:92–94.
3. De Smet L, Fabry G. Aseptic tenosynovitis of the flexor sheath due to a retained wooden splinter. *Acta Orthop Belg.* 1994;60:248–249.
4. Nelson EW, DeHart MM, Christensen AW, Smith DK. Magnetic resonance imaging characteristics of a lead pencil foreign body in the hand. *J Hand Surg Am.* 1996;21:100–103.
5. Marquis GP. Radiolucent foreign bodies in the hand: case report. *J Trauma.* 1989;29:403–404.
6. Bonatz E, Robbin ML, Weingold MA. Ultrasound for the diagnosis of retained splinters in the soft tissue of the hand. *Am J Orthop.* 1998;27: 455–459.
7. Mathur N, Sharma KK, Tiwari VK. An unusual foreign body in hand: a case report. *J Hand Surg Br.* 1986;11:135–136.
8. Middha VP, Vaishya R. Lesions produced by splinters of wood in soft tissues and bone. *Int Orthop.* 1990;14:47–48.
9. Booher JM, Thibodeau GA. *Athletic Injury Assessment.* 2nd ed. St. Louis, MO: Times Mirror/Mosby College Publishing; 1989:149–150.
10. American Academy of Orthopaedic Surgeons. *Athletic Training and Sports Medicine.* 2nd ed. Park Ridge, IL: American Academy of Orthopaedic Surgeons; 1991:207–209.
11. Anderson MA, Newmeyer WL 3d, Kilgore ES Jr. Diagnosis and treatment of retained foreign bodies in the hand. *Am J Surg.* 1982;144:63–67.
12. Hoffman DR, Jebson PJ, Steyers CM. Nail gun injuries of the hand. *Am Fam Physician.* 1997;56:1643–1646.
13. Sudoh AC. Tetanus: a case report. *Minn Med.* 1997;80:43–46.
14. Beasley RW. *Hand Injuries.* Philadelphia, PA: WB Saunders; 1981: 84–86.

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Snapping Iliopsoas Tendon in a Recreational Athlete: A Case Report

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Objective: To describe the evaluation, diagnosis, and conservative treatment of a 31-year-old female recreational athlete with a snapping iliopsoas tendon.

Background: The iliopsoas tendon has been implicated as an inflamed structure in this unique form of snapping hip. Hip pain, limitation of motion, or both may severely restrict vocational and recreational function and activities of daily living.

Differential Diagnosis: Left snapping hip syndrome secondary to the iliopsoas tendon or the iliotibial band.

Treatment: The treatment goal was to restore the athlete's pain-free, functional abilities. The primary focus of the treatment program was stretching of the left hip flexors. The patient demonstrated reduced pain and improved function following a 4-week stretching program and was fully functional and symptom free at 6 months.

Uniqueness: Snapping hip syndrome is a clinical entity that may be described as hip pain associated with an audible snap of the hip during motion. The most common and well-known cause of this syndrome involves the snapping of the iliotibial band over the greater trochanter. A less common cause is the snapping of the iliopsoas tendon over the iliopectineal eminence.

Conclusions: Understanding the anatomy and function of the iliopsoas tendon and related structures provides a basis for evaluation and treatment of this unique problem.

Key Words: snapping hip syndrome, hip pathology, hip rehabilitation

The hip plays an integral role in a variety of functional activities. The hip is essential for normal mobility and stability of the lower extremities and the trunk during weightbearing activities. Hip pain, limitation of motion, or both can severely limit normal and athletic function.

A snapping hip is a clinical entity described as hip pain associated with an audible snap of the hip during motion. The etiology of snapping hip syndrome is varied but generally involves a tendon snapping over a bony prominence. The most common and well-known cause involves the snapping of the iliotibial band over the greater trochanter.[1–3] Other less common causes are the snapping of the iliopsoas tendon over the iliopectineal eminence,[2,4,5] the snapping of the iliopsoas tendon over the femoral head and the anterior hip capsule,[1] and fibrosis of the gluteus maximus.[6] Additional etiologic factors include loose bodies, subluxation of the hip, synovial chondromatosis, and osteocartilaginous exostosis.[2,3]

Treatment of individuals with snapping hip is directed toward restoring pain-free functional abilities. An accurate diagnosis is essential to meet this goal in an effective and efficient manner. However, the varied causes and etiologies of snapping hip present a diagnostic challenge for the clinician. Our purpose is to describe the evaluation, diagnosis, and treatment of a patient with a snapping hip caused by the iliopsoas tendon. We present the anatomy and proposed pathomechanics of the iliopsoas tendon and related structures to augment the clinical case presentation.

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CASE PRESENTATION

The patient was a 31-year-old female who described a chronic history of popping in the left hip that became painful approximately 1 month before she sought medical intervention. Her primary complaints were pain, popping, and decreased functional abilities. The patient's goal was to return to pain-free functional activities. She was unable to identify any specific factors that may have contributed to the onset of pain and popping. Relevant past medical history included a left anterior cruciate ligament reconstruction in 1991 that remained stable and asymptomatic. The patient was placed on a course of nonsteroidal anti-inflammatory medication (Feldene, 20 mg daily; Pfizer Inc, New York, NY) for 14 days.

Functional Status

The patient was an active individual who regularly participated in a variety of recreational activities. She was concerned about the hip pain and her reduced function. Specific examples of functional limitations included jumping, crossing the left lower extremity over to the right, getting in and out of a car, and recreational running. Before the onset of pain, the patient ran 9 to 12 miles (14.48 to 19.31 km) per week. She had discontinued recreational running after the pain began because of increased left hip pain at distances of less than a mile. These restrictions did not significantly limit her work as a college professor or restrict activities of daily living.

Assessment and Diagnosis

On physical examination, active and passive range of motion of bilateral lower extremities was within normal limits and pain free except that passive extension of the left hip was painful at end range. When the left hip was actively moved from a flexed, externally rotated, and abducted position toward extension, a popping sound was present, reproducible, and associated with pain. Strength of bilateral extremities was assessed using manual muscle testing and was within normal limits, except for increased pain with resisted contraction of the left hip flexors. Neurovascular status and gait were within normal limits. However, with increased symptoms, the patient reported that she would limp. Palpation of the hip revealed no areas of tenderness. X-rays of the hip revealed no bony abnormality. The diagnosis was made of left snapping hip syndrome due to the iliopsoas tendon.

Clinical Course

After physical therapy evaluation, the patient was instructed in stretching exercises for the left hip, which would serve as her home exercise program (Figure 1, A and B). The patient was advised to complete 10 repetitions of each stretch to tolerance, with a hold of 30 seconds, twice per day. Suggestions for progression of activities, modalities, and alternative modes of exercise were also discussed with the patient. She participated in the home exercise program for 4 weeks, reporting compliance and demonstrating good tolerance to stretching activity. At re-evaluation, we noted significant improvement in the status of her left hip. She reported minimal pain and clicking or pain with functional activities and was able to run 12 miles (19.31 km) per week without increasing pain. Six months after treatment began, she was symptom free and able to participate regularly in a variety of exercises, including recreational running and stair stepper and stretching exercises.

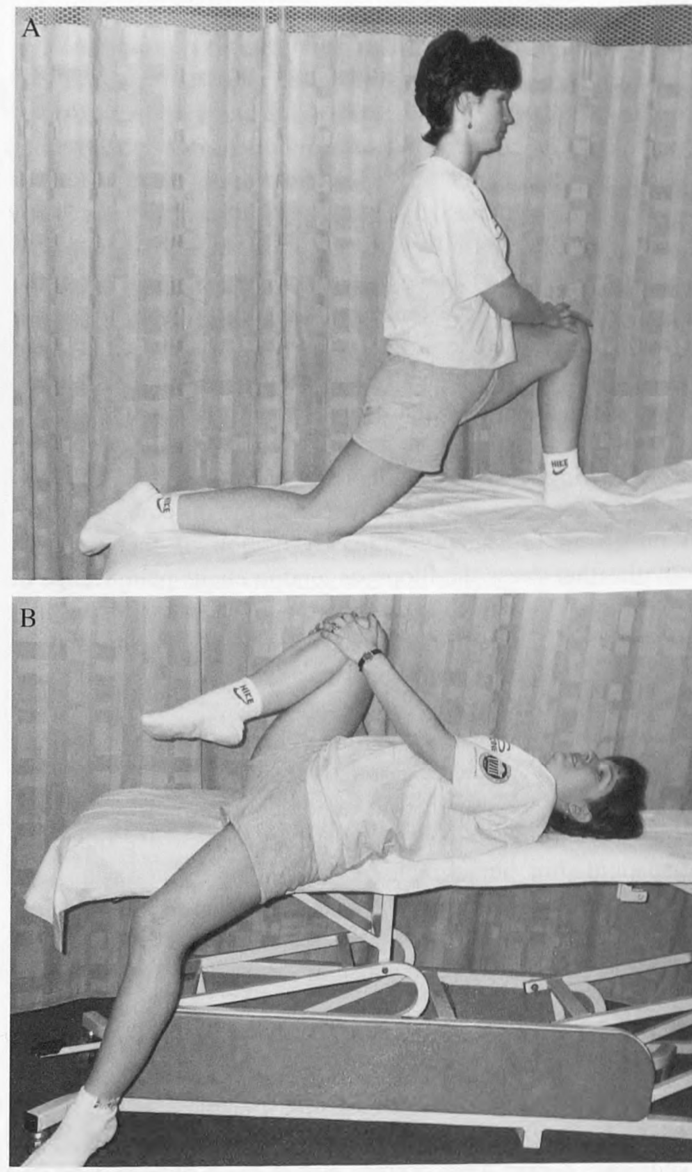

Figure 1. A and B, Two methods for self-stretching the iliopsoas as a component of the home exercise program. The iliopsoas is stretched by moving the hip into extension and avoiding excessive knee flexion.

DISCUSSION

A thorough understanding of the anatomy of the iliopsoas tendon and its relationship to the iliopectineal eminence and other structures is important to understand the cause of this problem and to treat it effectively. The psoas muscle originates from the transverse processes and bodies of all the lumbar vertebrae. The proximal attachment of the iliacus is the iliac fossa. These fibers blend into the lateral side of the psoas tendon. The conjoined iliopsoas tendon passes lateral to the iliopectineal eminence and medial to the joint capsule of the hip to insert on the lesser trochanter of the femur. With extension of the flexed, abducted, and externally rotated hip, the iliopsoas moves in a medial direction.[1,4] The iliopsoas bursa is found posterior to the iliopsoas, anterior to the hip joint.

One documented mechanism involves the snapping of the iliopsoas tendon over the lesser trochanter or the iliopectineal eminence.[2,4,5] An additional hypothesized anatomical factor is the snapping of the iliopsoas tendon over the femoral head and the anterior hip capsule.[1] Repetitive motion of the iliopsoas tendon may eventually lead to inflammation and pain. The iliopsoas bursa may be a logical source of some anterior hip pain. However, several authors[1,5] have found minimal evidence of an enlarged or inflamed bursa in patients with snapping hip. Although rare, intra-articular pathology (loose bodies) must be considered and ruled out.

Accurately determining the cause of the snapping is essential in developing an effective treatment plan. The diagnosis of snapping hip syndrome includes anterior hip pain, reduced function, and audible clicking.[1,2,4] This snapping iliopsoas tendon must be distinguished from the more common form of snapping hip involving the iliotibial band. For a comparison of clinical findings between iliopsoas and iliotibial band snapping hip, see the Table.

Individuals with a snapping hip are generally unable to report a specific causative factor, and the onset of symptoms may be vague. Pain is generalized to the anterior aspect of the hip (groin), with occasional pain radiating into the L4–5 dermatome.[8] Restrictions in functional activities are evident when the hip moves from a flexed to an extended position. An example of a common functional activity would be transferring from sitting to standing, or more specifically, getting out of a car, ascending and descending stairs, or running and jumping.

The iliopsoas tendon is implicated as the inflamed structure in this form of snapping hip. Evaluation of the hip with activities that stress the iliopsoas tendon elicits pain. Range of motion in the involved hip may be limited, and moving into extension may be painful. Resistance of the hip flexors may be weak and painful. Pain and an audible clicking may be reproduced by extending the flexed, abducted, and externally rotated hip. Palpation may be limited due to the location of the tendon.

All patients should undergo standard radiographs to rule out intra-articular and pelvic problems. To confirm the diagnosis of snapping hip, bursography of the hip under fluoroscopy can be performed.[9,10] However, this is usually reserved for resistant cases. Visual confirmation of the snapping of the iliopsoas tendon across the iliopectineal line from a lateral to a medial position can be made as the hip is moved from a flexed, abducted, and externally rotated position into extension (Figure 2, A and B). Movement is concurrent with an audible, palpable, and painful snap, confirming the original diagnosis.[9,10] Schaberg et al[2] reported that, in 8 patients with snapping hip syndrome, X-rays were normal. But of the 6 patients who had iliopsoas bursography, 5 were found to have a snapping iliopsoas tendon.

Treatment goals in the conservative management of iliopsoas snapping hip include (1) restoring normal, pain-free range of motion and strength; (2) returning to pain-free functional (vocational, recreational, daily living) capabilities; and (3) identifying and modifying any contributing factors. The major component of the treatment plan is stretching exercises de-

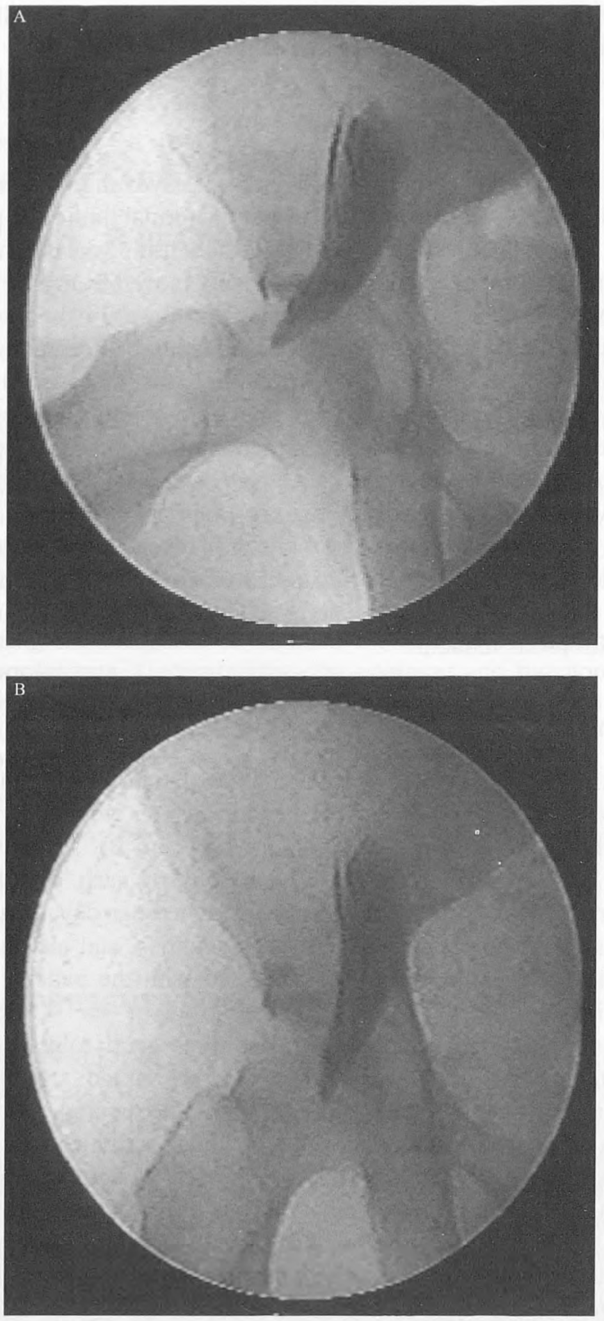

Figure 2. Iliopsoas bursography, with the hip in a flexed, externally rotated and abducted position (A) and the hip in a neutral position (B). Note the medial position of the tendon in (B) when compared with (A).

Comparison Between Significant Clinical Findings in Iliopsoas and Iliotibial Snapping Hip (adapted with permission from Starkey and Ryan[7])

Evaluation	Iliotibial Band	Iliopsoas Muscle
Pain location	Over the greater trochanter, radiating posteriorly to the buttock	Generalized to the anterior aspect of the hip (groin)
Palpation	Tenderness over the trochanteric bursa	Palpation may be limited due to the location of the structure
Mobility	Hip flexion-extension and internal-external rotation, adduction decreased and painful	Hip extension limited and painful
Strength	Hip extension and abduction painful and may be weak	Hip flexion may be weak and painful
Special tests	Ober test	Extending the hip from a flexed, abducted, and externally rotated position reproduces pain and popping

signed to improve the mobility of the iliopsoas tendon and other anterior hip structures. Both active and passive stretching exercises that include hip and knee extension should be the focus of the program. Stretching the hip into extension and limiting excessive knee flexion avoids placing the rectus femoris in a position of passive insufficiency, thereby maximizing the stretch to the iliopsoas tendon. Strengthening exercises for the hip flexors may also be an appropriate component of the program. A home exercise program is essential. Patient education and nonsteroidal anti-inflammatory medication, as well as activity modification or activity progression (or both), may be helpful. Conservative measures generally resolve the problem in 6 to 8 weeks.[1]

Aggressive management of iliopsoas snapping hip includes corticosteroid injection of the hip and surgery. Surgical treatment should be considered following a lack of significant functional improvement with conservative management. Given the variability in patients, it is difficult to specify a duration for conservative intervention. The surgical option should be evaluated in the context of patient goals, functional status, patient pain, and prior treatment outcomes. Surgical intervention may include lengthening of the iliopsoas tendon and resection of a bony spur at the lesser trochanter.[1,2,5,9] Satisfactory outcomes after surgery have been reported as reduced symptoms, decreased pain, and increased function (eg, walking, pole vaulting, running, and competitive football).[1,2,9] The duration of symptoms before surgery for these patients ranged between 9 months and 9 years.

SUMMARY

A snapping hip involving the iliopsoas tendon is an infrequently encountered entity. Understanding the anatomy and function of the iliopsoas tendon and related structures provides a basis for evaluation and treatment. Accurate diagnosis of the problem can serve to facilitate effective treatment and result in a satisfactory outcome. Conservative management focuses on appropriate stretching exercises and nonsteroidal anti-inflammatory medication. Surgical lengthening of the iliopsoas tendon appears to be beneficial in some instances where outcomes resulting from conservative management are unsatisfactory.

ACKNOWLEDGMENTS

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REFERENCES

1. Jacobson T, Allen WC. Surgical correction of the snapping iliopsoas tendon. *Am J Sports Med.* 1990;18:470–474.
2. Schaberg JE, Harper MC, Allen WC. The snapping hip syndrome. *Am J Sports Med.* 1984;12:361–365.
3. Zoltan DJ, Clancy WG Jr, Keene JS. A new operative approach to snapping hip and refractory trochanteric bursitis in athletes. *Am J Sports Med.* 1986;14:201–204.
4. Lyons JC, Peterson L. The snapping iliopsoas tendon. *Mayo Clin Proc.* 1984;59:327–329.
5. Rotini R, Spinozzi C, Ferrari A. Snapping hip: a rare form with internal etiology. *Ital J Orthop Traumatol.* 1991;17:283–288.
6. Brignall CG, Brown RM, Stainsby GD. Fibrosis of the gluteus maximus as a cause of snapping hip. *J Bone Joint Surg Am.* 1993;75:909–910.
7. Starkey C, Ryan J. *Evaluation of Orthopedic and Athletic Injuries.* Philadelphia, PA: FA Davis; 1996:224.
8. Hertling D, Kessler RM. *Management of Common Musculoskeletal Disorders.* 3rd ed. Philadelphia, PA: Lippincott; 1996:295–305.
9. Harper MC, Schaberg JE, Allen WC. Primary iliopsoas bursography in the diagnosis of disorders of the hip. *Clin Orthop.* 1987;221:238–241.
10. Vaccaro JP, Sauser DD, Beals RK. Iliopsoas bursa imaging: efficacy in depicting abnormal iliopsoas tendon motion in patients with internal snapping hip syndrome. *Radiology.* 1995;197:853–856.

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The Laser-Assisted Capsular Shift Procedure on an Intercollegiate Volleyball Player: A Case Report

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Objective: To present a new arthroscopic technique, the laser-assisted capsular shift (LACS), which decreases glenohumeral instability and reduces recovery time over traditional surgical procedures.

Background: A student-athlete hyperabducted her right shoulder while diving for a ball during a volleyball match. She complained of pain, weakness, and inability to raise her arm above shoulder height in any plane.

Differential Diagnosis: Capsular sprain, subluxation, rotator cuff strain, glenoid labral lesion.

Treatment: The student-athlete was unable to play due to pain and dysfunction and so elected to have the LACS procedure performed.

Uniqueness: The LACS procedure is a relatively new procedure for tightening the capsule and decreasing glenohumeral instability. Immobilization and recovery time are reduced when compared with traditional treatment methods.

Conclusions: The LACS procedure appears to be a good alternative to some of the traditional methods used to treat glenohumeral instability.

Key Words: arthroscope, instability, glenohumeral, shoulder injury

The laser-assisted capsular shift (LACS) procedure is a relatively new procedure used to shrink or tighten the capsule of the shoulder in multidirectional instability.[1] Thermal energy applied to the collagen of the shoulder capsule leads to a decrease in capsule tissue tensile strength and an increase in capsular stiffness.[2] Tissue shrinkage occurs between 60°C and 70°C. The heat and time used, in addition to the laser itself, appear to affect the collagen.[2]

Many surgical procedures have been developed to reduce multidirectional instability, but they require an extensive recovery period.[3–6] The recovery period to return to activity ranges from 4 to 12 months.[7–12] The LACS is performed through an arthroscope, so it is less invasive. The immobilization period is short, approximately 1 week, which potentially reduces the recovery time.[13] This immobilization period has also been corroborated by W.P. Thorpe, MD (written communication, July 1994). The purpose of this technique is to reduce instability and potentially reduce recovery time.

ANATOMY OF THE GLENOHUMERAL JOINT

The bony structures of the shoulder complex and joint are the clavicle, scapula, and humerus. The head of the humerus articulates with the glenoid fossa of the scapula to form the glenohumeral joint. The glenoid's articular surface is pear shaped, with an inferior half 20% larger than the superior half.[14] The articular cartilage of the glenoid fossa is thickest in the periphery and thinnest in the center.[14] Only 25% to 30% of the humeral head is covered by the glenoid in any position of rotation.[15] This joint has been compared with a golf ball sitting in a tee.[15] A rim of fibrocartilage called the labrum surrounds the glenoid fossa. The labrum deepens the glenoid fossa by 50% and serves as the attachment site for ligaments.[15] The superior attachment of the labrum is loose, and the inferior attachment is firm and unmoving.[14]

The capsule is attached medially to the margin of the glenoid fossa and laterally to the circumference of the anatomical neck, descending about 1.3 cm onto the shaft of the humerus. It is thin and large, allowing 2 to 3 mm of distraction of the head from the glenoid.[16] The joint capsule is composed of multilayered collagen fiber bundles of different strengths and orientations. The anteroinferior capsule is the thickest and strongest portion of the capsule due to the densely organized collagen fibers. The orientation of the collagen fibers provides and absorbs tension, which leads to a centering or stabilizing of the joint.[14]

CASE HISTORY

During the fourth game of a match, a 22-year-old intercollegiate volleyball player dove to the right for a ball and hyperabducted her right shoulder. She complained of pain,

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weakness, and inability to raise her arm above shoulder height in any plane. The relocation, anterior drawer, apprehension, sulcus, and clunk tests were all positive.[17,18] There was also a painful arc of 60° to 90° of abduction with weakness. No posterior laxity was evident. Examination of the uninjured shoulder was normal, and there was no history of previous instability in either shoulder. The athlete was seen by the team orthopaedist, whose diagnosis was multidirectional instability with a possible labral tear. With 3 matches left in the season, the decision was to rehabilitate the shoulder with the possibility of the athlete's playing back row only. The athlete was unable to play due to pain and dysfunction and so elected to have arthroscopic surgery.

The LACS technique was used to tighten the capsule and eliminate multidirectional instability. The patient underwent the LACS procedure on November 15. According to the surgical report, the arm was placed in a shoulder traction device with 6.8 kg (15 lb) of weight in manual traction. A 5-mm, 30° arthroscope and various accessory instruments were introduced into the shoulder through anterior and posterior portals. Traction during examination under anesthesia revealed anterior and inferior shoulder instability, with the humeral head 75% to 95% off the glenoid. The capsule was intact, but lax. The labrum was very thin, but not torn. The articular surface of the humerus and glenoid contained Outerbridge grade 2 lesions.[19] The holmium:yttrium aluminum garnet (YAG) laser was applied repeatedly to the anterior capsule to cause a contraction, resulting in tightening of the anteroinferior capsule. The athlete left surgery in good condition and was placed in a shoulder immobilizer.

She remained in the immobilizer for 1 week and on November 22 began the LACS rehabilitation program we designed, starting with passive range of motion in all ranges (Table 1). On November 27, the athlete progressed to isometric exercises with the arm at the side. On November 30, she began a closed kinetic chain progression (Table 2), including an upper body exerciser for moderate- to high-speed exercise at 90°/s to 120°/s (phase 3). On December 7, she advanced to active range-of-motion and isotonic exercises in all ranges of motion (phase 4). Scapular stabilization exercises consisting of scapular elevation, depression, and adduction began on January 5 (phase 5). Isokinetic exercises at moderate to high speed, 180°/s to 240°/s, with the elbow flexed to 90° and the shoulder slightly abducted, started on January 17. The athlete was released from the physician's care on February 8, 11 weeks postarthroscopy, with full active range of motion, no signs of instability, and good strength. She began setting, passing, serving, digging, spiking, and blocking with limited repetitions and progressed as tolerated. Exercise continued with upper body weights in the weight room, which included military, bench press, and pull-downs (phases 7 and 8). The athlete participated in volleyball during the offseason without incident and was very satisfied with the surgery. At 3 years after surgery, she is coaching and playing volleyball without pain or dysfunction.

DISCUSSION

The athlete participated in preoperative and postoperative physical examinations and completed preoperative and postoperative written surveys, which evaluated range of motion, pain level, strength, and discomfort during daily living activities.[20] Active range-of-motion measurements increased preoperatively to postoperatively in flexion by 40°, abduction by 70°, adduction by 50°, and internal and external rotation, with the shoulder abducted to 90°, by 53° each. Extension did not increase postoperatively. The pain level at the time of the preoperative survey was classified as severe (constant discomfort, limits activity). At 11 weeks postsurgery, pain was classified as mild (occasionally, only with activity, does not limit activity). Many of the activities of daily living that the athlete found difficult before surgery were performed without difficulty after surgery. Examples of these are hair washing and combing, putting on a jacket and finishing with the affected shoulder, getting clothing from a shelf above shoulder level, and opening a car door.

We designed the rehabilitation program specifically for the LACS procedure. The program allows patients to progress at their own pace and within their own limitations. Progression to the next phase depends upon active range of motion and the ability to perform the exercises of the phase without pain. No above-shoulder active range of motion is allowed for 3 weeks from the date of the surgery. This athlete was able to progress easily through the phases and rehabilitated on her own at home over semester break, for approximately 1 month. She had regained full passive and active range of motion in all ranges of the shoulder 12 days after immobilization was discontinued. The athlete participated in rehabilitation for 2.5 months.

The LACS is used today in patients with glenohumeral instability. This procedure is a promising alternative to techniques, open and closed, used to create stability within the shoulder. The procedure employs a laser to shrink tissue in the shoulder capsule, which allows function and mobility to return.[1] Results and long-term follow-ups are few due to the newness of this procedure.

CONCLUSIONS

The LACS appears to be a good alternative to some of the traditional methods used to treat glenohumeral instability. This intercollegiate student-athlete was able to return to competitive activity without complaint and without instability. The rehabilitation program described is a very aggressive program that allows an early return to activity. The use of phases allows individuals to progress according to their own paces and limitations. Early full active and passive range of motion is the key to early return to activity. This rehabilitation program also combines open kinetic chain exercises with closed kinetic chain exercises. Further research is needed to study the longitudinal effects of the LACS procedure, as well as the rehabilitation program, on a physically active population.

Table 1. LACS Rehabilitation Protocol

Phase 1
- Immobilized in sling

Phase 2
- Immobilization removed
- Codman/pendulum exercises
- Passive flexion-extension
- Passive abduction-adduction
- Passive horizontal abduction-adduction
- Passive internal-external rotation with shoulder adducted and elbow flexed to 90°
- Wall climbing, table walking
- Isometric exercises: hold 6 s with shoulder adducted and elbow flexed to 90°
- Active range of motion (AROM): all ranges except internal-external rotation with abduction to 90°
- Cardiovascular (CV) activity of choice
- Activities of daily living

Phase 3
- Continue Codman/pendulum exercises
- Continue isometric exercises
- Begin active-assisted ROM in same ROM if necessary
- Upper body exerciser (UBE) for ROM at moderate to high speed (90° to 120°)
- Begin closed kinetic chain exercise progression (see Table 2)
- Begin elbow, wrist, and hand isotonic exercises
- CV activity of choice
- If active ROM almost full, begin isotonics

Phase 4
- Continue active-assisted ROM if needed
- Continue closed kinetic chain progression (see Table 2)
- AROM
- Begin AROM internal-external rotation at 90° of abduction
- Continue UBE
- Begin isotonic dumbbell exercise, all ROMs
  - Flexion-extension
  - Abduction-adduction
  - Horizontal abduction-adduction
  - Internal-external rotation with arm adducted and elbow flexed to 90°
  - Internal-external rotation at 90° of abduction and elbow flexed to 90°
  - Elevation-depression
  - Protraction-retraction
  - Scaption with internal rotation
  - Scaption with external rotation
  - Horizontal abduction with medial rotation at 0°, 30°, and 90°
  - Horizontal abduction with lateral rotation at 0°, 30°, and 90°
- CV activity of choice

Phase 5
- Begin scapular stabilization exercises (scapular adduction)
- Progress weight in isotonics as tolerated
- Continue closed kinetic chain progression (see Table 2)
- CV activity of choice

Phase 6
- Continue isotonic exercise
- Continue closed kinetic chain progression (see Table 2)
- Continue scapular stabilization exercises
- Begin isokinetic exercise at high speed with arm in slight abduction and elbow flexed (180° to 300°)
- Begin tubing exercises: flexion-extension, abduction-adduction, and horizontal abduction-adduction
- CV activity of choice

Phase 7
- Continue above exercises and progress as tolerated
- Begin pull-downs (front and back), military, bench press, cleans, and squats if indicated
- CV activity of choice

Phase 8
- Continue exercises from Phase 6
- Begin sport- and activity-related exercises of choice
- Proprioceptive neuromuscular facilitation patterns if indicated
- Throwing athletes begin throwing protocols
- Employ drills that use the shoulder in practice and activity

Cautionary notes
- Not all patients will return in 2 mo.
- Patients should progress at their own pace, reducing weight, exercises, or both, if they develop pain.
- Always maintain full active ROM.
- No overhead activity until at least 3 wk postoperatively.
- Check with the patient's physician before implementing this program.

Table 2. Closed Kinetic Chain Progression

Double-arm wall push-aways: short distance, 15.24 cm (6 in)
Double-arm wall push-aways: long distance, 30.48 cm (12 in)
Single-arm wall push-aways: short distance, 15.24 cm (6 in)
Single-arm wall push-aways: long distance, 30.48 cm (12 in)
Ball toss: chest, single arm, spatial awareness
Press up from chair
Rowing
Bent-knee and bent-arm pushup
Bent-knee and straight-arm pushup
Straight-leg pushup, bent arm
Straight-leg pushup, straight arm
Wheel barrel pushup
Catching large balls
Side-to-side walking on hands
Slideboard: side to side and circles
Swedish ball exercises
Notes
Patients should progress at their own pace.
Closed kinetic chain exercises were chosen from the above list for our patient.
Other closed kinetic chain exercises can be substituted as long as the patient progresses from beginning to advanced exercises.

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REFERENCES

1. Ogle K. Laser "shrinks" shoulder capsule tissue. *Orthop Today.* 1994;14:1–3.
2. Nottage WM. Laser-assisted shoulder surgery. *Arthroscopy.* 1997;13:635–638.
3. Bigliani LU, Kurzweil PR, Schwartzbach CC, Wolfe IN, Flatow EL. Inferior capsular shift procedure for anterior-inferior shoulder instability in athletes. *Am J Sports Med.* 1994;22:578–584.
4. Guanche CA, Quick DC, Sodergren KM, Buss DD. Arthroscopic versus open reconstruction of the shoulder in patients with isolated Bankart lesions. *Am J Sports Med.* 1996;24:144–148.
5. Montgomery WH 3d, Jobe FW. Functional outcomes in athletes after modified anterior capsulolabral reconstruction. *Am J Sports Med.* 1994;22:352–357.
6. Zarins B, McMahon MS, Rowe CR. Diagnosis and treatment of traumatic anterior instability of the shoulder. *Clin Orthop.* 1993;291:75–84.
7. Liu SL, Henry MH. Anterior shoulder instability: current review. *Clin Orthop.* 1996;323:327–337.
8. Jobe FW, Giangarra CE, Kvitne RS, Glousman RE. Anterior capsulolabral reconstruction of the shoulder in athletes in overhand sports. *Am J Sports Med.* 1991;19:428–434.
9. Caspari RB, Beach WR. Arthroscopic anterior shoulder capsulorrhaphy. *Sports Med Arthrosc Rev.* 1993;1:237–241.
10. Lusardi DA, Wirth MA, Wurtz D, Rockwood CA Jr. Loss of external rotation following anterior capsulorrhaphy of the shoulder. *J Bone Joint Surg Am.* 1993;75:1185–1192.
11. Pagnani MJ, Warren RF. Multidirectional instability: medial T-plasty and selective capsular repairs. *Sports Med Arthrosc Rev.* 1993;1:249–258.
12. Cooper RA, Brems JJ. The inferior capsular-shift procedure for multidirectional instability of the shoulder. *J Bone Joint Surg Am.* 1992;74:1516–1521.
13. Thabit G. Treatment of unidirectional and multidirectional glenohumeral instability by an arthroscopic holmium:YAG laser-assisted capsular shift procedure: a pilot study. In: *Laser Application in Arthroscopy.* Neuchatel, Switzerland: The International Musculoskeletal Laser Society; 1994.
14. Wilk KE, Arrigo CA, Andrews JR. Current concepts: the stabilizing structures of the glenohumeral joint. *J Orthop Sports Phys Ther.* 1997;25:364–379.
15. Matsen FA, Fu FH, Hawkins RJ, eds. *The Shoulder: A Balance of Mobility and Stability.* Rosemont, IL: American Academy of Orthopaedic Surgeons; 1993:7–81.
16. Culham E, Peat M. Functional anatomy of the shoulder complex. *J Orthop Sports Phys Ther.* 1993;18:342–350.
17. Wilk KE, Andrews JR, Arrigo CA. The physical examination of the glenohumeral joint: emphasis on the stabilizing structures. *J Orthop Sports Phys Ther.* 1997;25:380–389.
18. Magee DJ. *Orthopedic Physical Assessment.* Philadelphia, PA: WB Saunders; 1997:175–221.
19. Mandelbaum BR, Browne JE, Fu F, et al. Articular cartilage lesions of the knee. *Am J Sports Med.* 1998;26:853–861.
20. Amstutz HC, Sew Hoy AL, Clark IC. UCLA anatomic total shoulder arthroplasty. *Clin Orthop.* 1981;155:7–20.

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A Reconditioning Program to Lower the Recurrence Rate of Brachial Plexus Neurapraxia in Collegiate Football Players

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Objective: To present clinical techniques for managing class I brachial plexus neurapraxia (BPN) in collegiate football players.

Background: During a football career, up to 50% of college football players develop BPN. It is difficult to return the player to practice and competition without many recurrences during the same season. Postseason reconditioning programs may improve the outcome by allowing the injured nerves a chance to heal adequately. Flexibility and strength of the neck and shoulder girdle are the focus of this proposed postseason BPN reconditioning program. This clinical technique is designed to reduce or eliminate inflammation, weakness, and hypomobility that contribute to reinjury of the brachial plexus and the resulting class I BPN.

Description: After the football season, the team physician performs a mandatory follow-up examination. Any pathology that may be exacerbated is ruled out before beginning this program. Conservative management is prescribed during the first 4 weeks postseason. Then an 8-week period of aggressive reconditioning is initiated. Players begin manual resistance and Nautilus neck machine exercises 3 times per week. A cervical spine mobilization and modified shoulder resistance program is performed 2 days per week. Subsequently, players proceed with modification of the general neck and shoulder program used by the rest of the squad. Shoulder pad and neck orthoses selection should be reviewed to ensure that the best protection against reinjury is used when the athlete returns to play. To minimize any chance of recurrence, a progressive pattern of gradually increasing collision work is employed after the athlete is cleared by the physician.

Clinical Advantages: Postseason observation of players after 1 year should reveal decreased recurrence of brachial plexus injury. The reconditioning program format, together with protective equipment considerations, may have a significant effect in reducing or eliminating the recurrence of BPN in football players.

Key Words: cervical nerve injury, mobilization, manual techniques, rehabilitation exercise

Each year, injuries to the brachial plexus plague football participants at all levels of competition. Up to 50% of football players may suffer a brachial plexus neurapraxia (BPN) during their careers.[1–4] No apparent single solution has completely relieved athletes of the effects of BPN during the football season, except for total abstinence from collisions involving the upper body.[3] Recurrence of BPN injuries can lead to long-term complications and disability.[5–9] My purpose is to present a comprehensive reconditioning protocol that may reduce the recurrence rate of this complex and debilitating problem.

Pathomechanics and Pathophysiology

Class I BPN is characterized as a traction or impingement injury of the cervical nerve roots or the brachial plexus (C5-T1). Episodes of BPN can be caused by a forceful blow to the head from the side with rapid lateral flexion, from cervical spine hyperextension, or from shoulder girdle depression.[10] A more common cause of BPN is compression from a blow to the supraclavicular region at Erb's point.[7,11] Symptoms usually last a few minutes, but prolonged symptoms can occur. Prolonged symptoms require that other problems such as C5-7 radiculopathy or cervical myelopathy be ruled out with radiography and magnetic resonance imaging.[12] Such pathology would prevent the athlete from participating in the program.[13] When symptoms last beyond 2 weeks, electromyography may reveal significant changes in neuromuscular function.[10] In the presence of chronic, repetitive BPN, complete cessation of collision activity may be required.[10]

Program Rationale

A program that eliminates inflammation, restores normal range of motion (ROM) and muscular strength to the neck and shoulder girdle musculature, and allows the time for a full, gradual recovery should reduce or eliminate the recurrence of BPN.[14] Program development is based on the time players have available between the fall and spring seasons, which allows for a 4-week conservative plan, followed by an 8-week reconditioning program. Intensity and volume for each athlete are determined by applying established therapeutic exercise

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techniques for cervical spine and shoulder reconditioning.[4,15] In contrast with other approaches, this program provides extended time for healing and emphasizes lateral flexion mobilization with shoulder strengthening. Lateral flexion is a main focus of the program due to the most reported mechanism of injury of BPN in football: depression of the shoulder girdle with extreme lateral flexion of the cervical spine during collision.[2,11]

Postseason Management

After the fall football season, players with class I BPN,[13,16–18] confirmed by the team physician, and no other cervical spine or shoulder girdle pathology begin the postseason exercise program.

Phase I: Conservative Program (4 Weeks)

The first component of this program starts immediately after the season and comprises 1 treatment session per day for 4 weeks. It involves reducing inflammation and maintaining ROM via the following methods:

1. prescription and administration of a nonsteroidal anti-inflammatory medicine by the team physician;
2. daily applications of moist heat packs to the neck and upper back for 20 minutes;
3. active range of all neck motions: flexion-extension, left-right rotation, and left-right lateral flexion with a slightly flexed cervical spine (30°) and with an upright posture in a seated position (10 repetitions each).

The athlete's postural alignment for the active motions emphasizes an upright-sitting, chest-forward, chin-down position during exercises. This ensures maintenance of open foramina for the spinal nerve roots during the exercises.[4] All strength and conditioning routines, such as presses and shrugs, that might aggravate existing problems must be avoided until this entire program is completed.

Phase II: Reconditioning Program (8 Weeks)

After the end of the conservative management program, the athlete who is medically asymptomatic and considered eligible by the medical and athletic training staff begins the reconditioning protocol. The regimen is as follows:

1. Employ the conservative program previously listed as a warm-up.
2. For 5 sessions per week (Mondays through Fridays), the athlete performs full-range neck movement from the supine position while receiving manual concentric and centric resistance. Resistance is provided by the athletic trainer throughout all 6 motions of the cervical spine (flexion-extension, left-right rotation, left-right lateral flexion) (Figure 1). Maximal effort is exerted by the athlete through each motion at a speed of about 4 to 5 cm per second. Four sets of 10 repetitions of these resistive exercises are completed each session. The sets:repetition ratio is based on progressive resistance protocol.[19] Weekends allow for a recovery phase at the end of each week.
3. Three days per week (Mondays, Wednesdays, and Fridays), the athlete performs 4 sets of 10 repetitions[19] on the Nautilus (Independence, VA) (or comparable) neck machine in each of the 4 motions available (flexion-extension, left-right lateral flexion)(Figure 2). These movements are performed through a full, active ROM. The athlete starts with the lightest available resistance of 4.54 kg (10 lb) on the neck machine so as to avoid triggering any relapse of symptoms and increases by 2.27 kg (5 lb) per week with a goal of 13.61 kg (30 lb) by the end of the 8-week cycle. The athlete may be given the daily adjusted progressive resistance exercise (DAPRE) technique[20] in the fourth set to allow for a more rapid progression of muscular strength development. Athletes who progress beyond 13.61 kg (30 lb) may be able to advance to the 22.68-kg (50-lb) maximum before the end of the 8-week cycle. This portion of the program can be completed during the general strength and conditioning component with the rest of the team.
4. On Tuesdays and Thursdays, 4 sets of 10 repetitions[19] of bilateral thumbs-up and palms-down modified shoulder abduction are performed. From a standing position, shoulder abduction is performed from arms at sides in normal anatomical position to 90° of abduction with thumbs pointed to the ceiling. Elbows are maintained in an extended position. This movement is then followed by a smooth return to normal anatomical position. This is followed immediately by performing shoulder flexion with both palms down in a full-range motion. After flexion is performed to 180°, the arms are returned to the sides to begin the next repetition[21] (Figure 3).
5. The final component of this reconditioning program consists of manual stretching and neck mobilization through all ranges of motion in all planes. This component is performed twice per week along with the modified shoulder abduction program described above. Areas in which the athlete lacked normal flexibility are mobilized in the form of hold-relax proprioceptive neuromuscular facilitation during the stretching session. At the end of the range being increased, a 3-oscillation/second pressure is used to improve the restricted motion[22] (Figure 4). The rationale for this program component is that addressing restricted ROM of the cervical spine reduces the likelihood of recurrence of class I BPN. Candidates for cervical spine mobilization must be chosen on the basis of their symptomatology. During mobilization, the athlete should experience only stretching as a local phenomenon. Any triggering of paresthesias, radiating pain, or return of other previous BPN symptoms stops the treatment session. This technique must be performed with minimal discomfort and halted if the athlete cannot tolerate the mobilization or becomes otherwise symptomatic. The athlete who becomes symptomatic is then

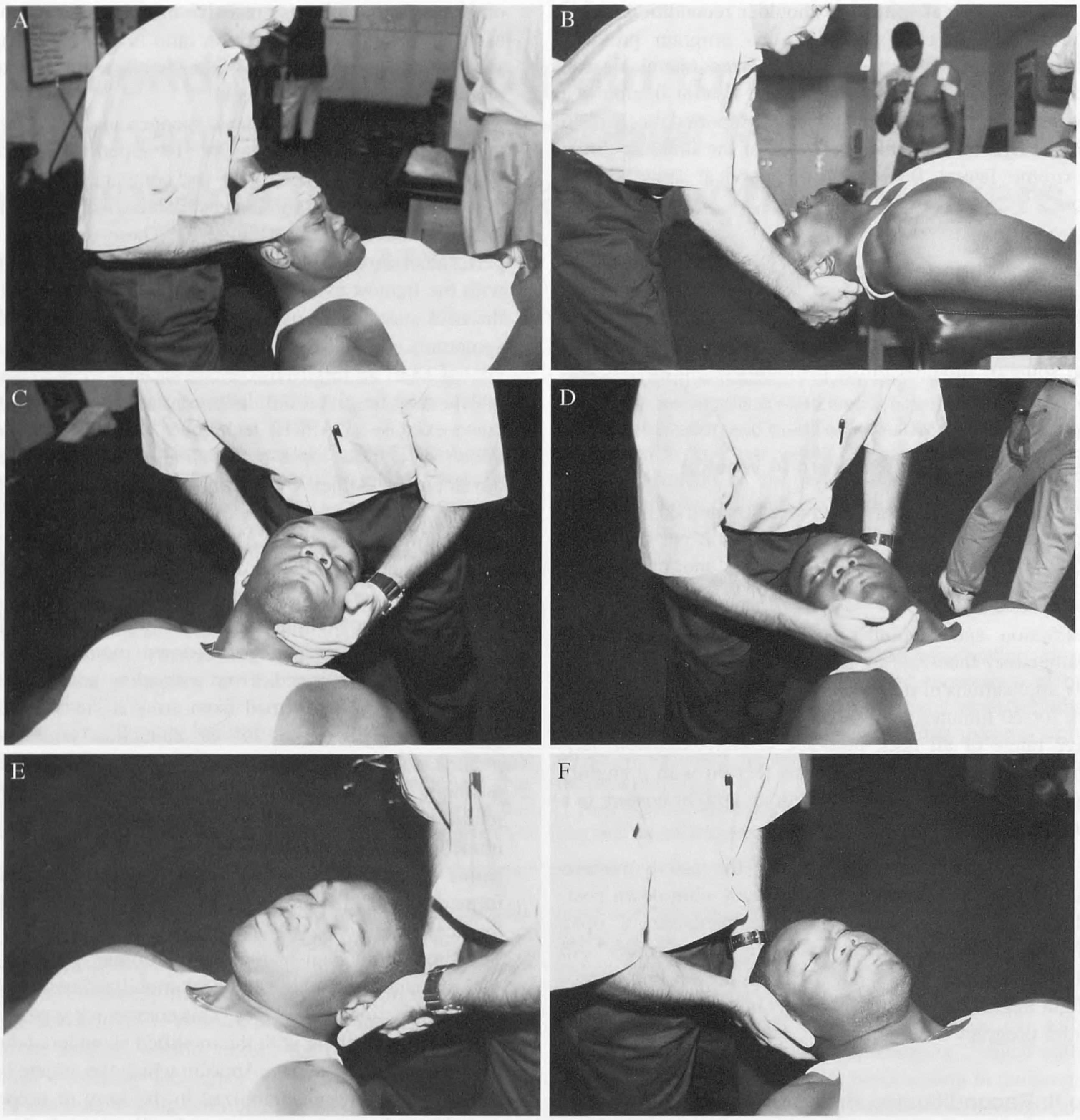
Figure 1. Manual resistance program. A, Flexion; B, extension; C, left rotation; D, right rotation; E, left lateral flexion; F, right lateral flexion.

automatically referred back to the team physician before receiving any more treatment.

The abduction-flexion shoulder routine and the cervical stretch-mobilization programs are carried out in the athletic training room under staff supervision. Cervical spine mobilization is performed by the athletic trainer and employed only with the expressed consent of the attending team physician and the student-athlete-patient. This program is employed during the off-season period from the last game in the fall to the start of spring practice.

Phase III: Criteria for Return to Full Participation

A gradual return to full participation is also important.[23–25] Noncollision drills followed by collision drills of an individual nature should be done first. Position-oriented skills followed by team offensive or defensive work should be addressed next. Finally, scrimmage work is explored on a down-by-down basis. This must be performed with near-constant communication and immediate intervention available between athlete and athletic trainer to ensure minimal risk in the return of possible signs or symptoms of recurrent BPN.

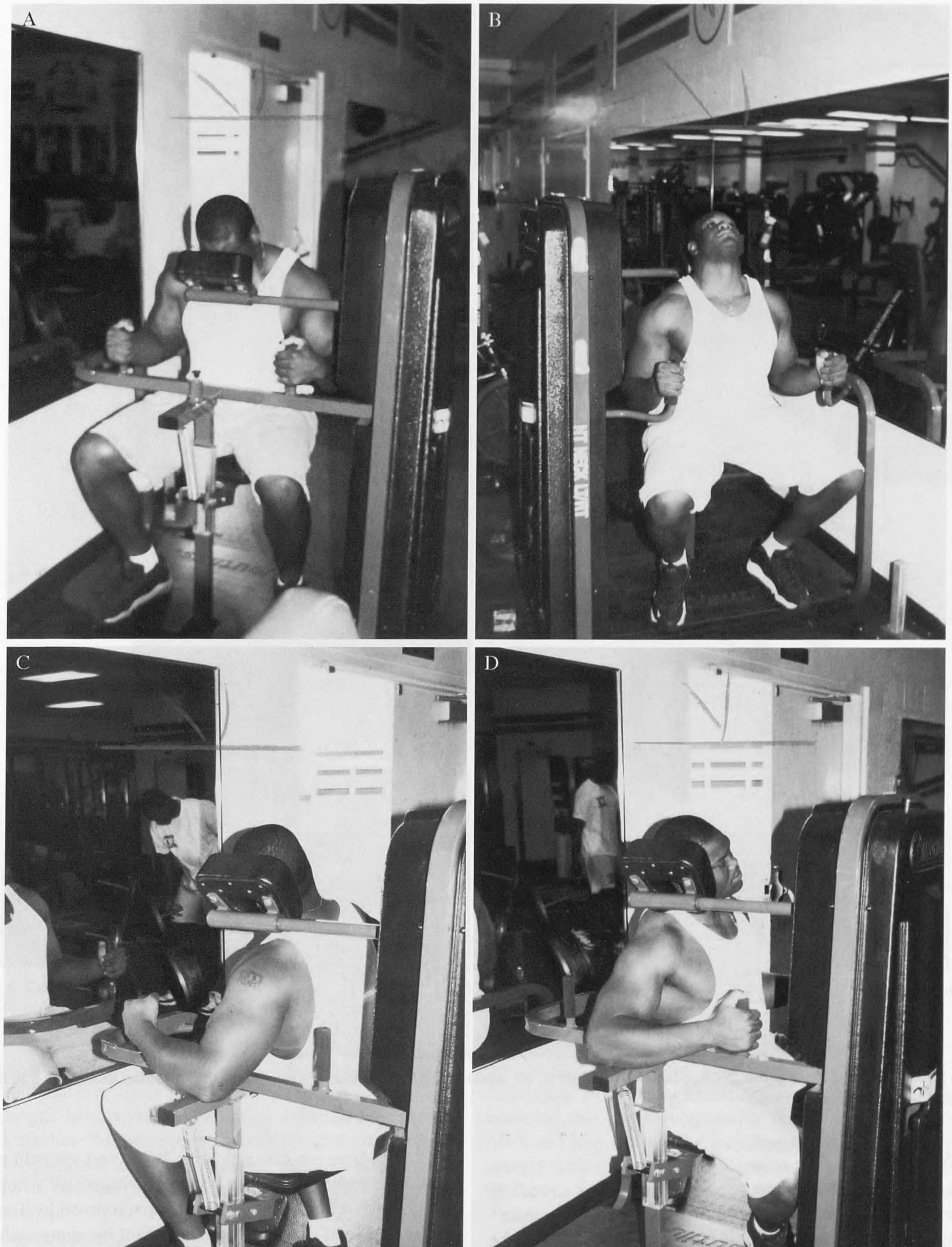

Figure 2. Nautilus neck machine. A, Flexion; B, extension; C, left lateral flexion; D, right lateral flexion.

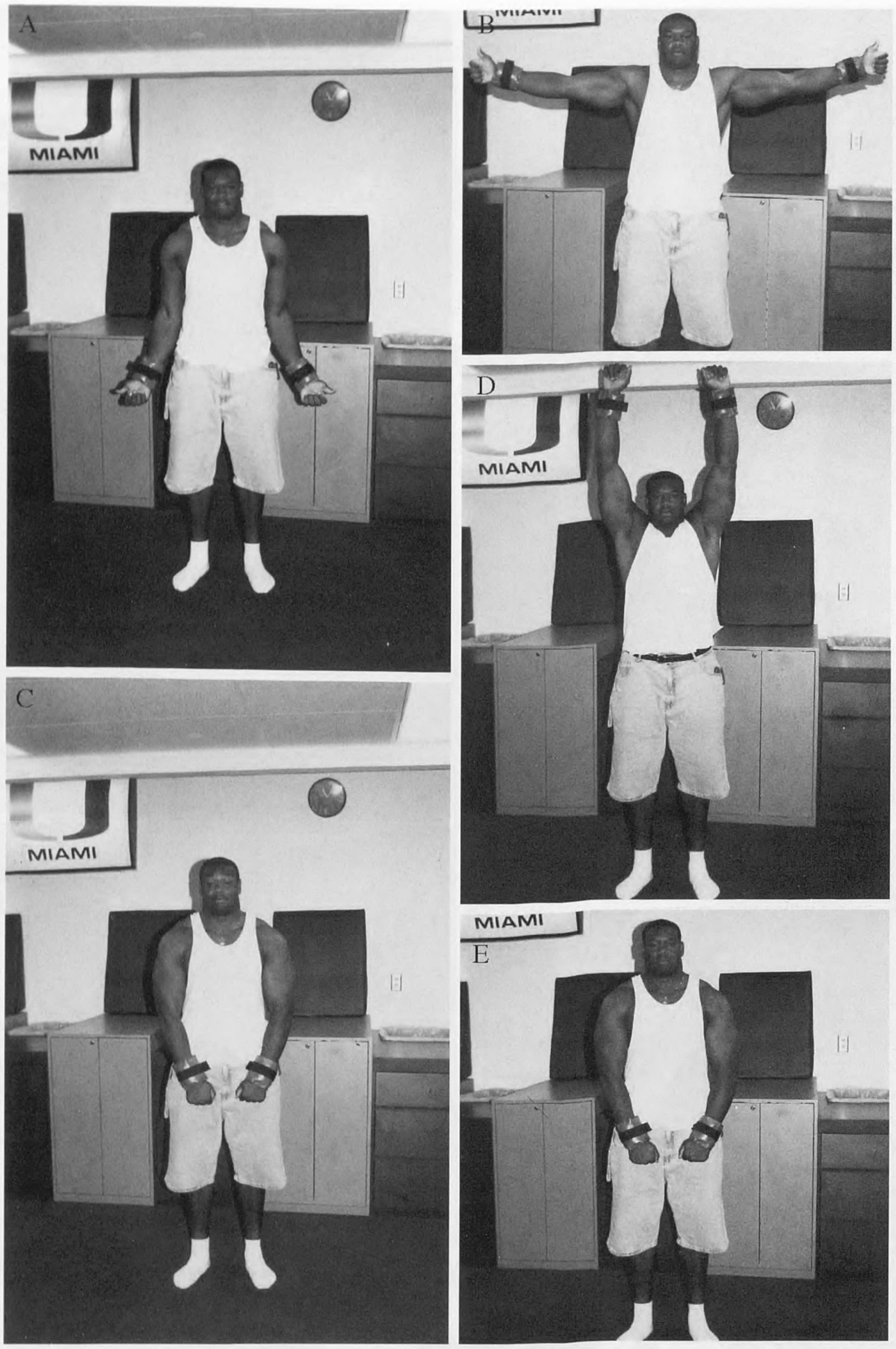

Figure 3. Modified shoulder program. A, Starting position; B, 90° abducted position, thumbs up; C, starting position flexion; D, full flexion position; E, end position.

DISCUSSION

Brachial plexus neurapraxia can occur, in part, as a result of deficient ROM of the cervical spine and shoulder girdle.[2] Lateral flexion deficiencies must be completely resolved for the best possible outcome, because cervical spine lateral flexion is integral in the mechanism of BPN in football.[2,15,26] Posttraumatic neck and shoulder strength deficits over the course of 1 or many seasons may also contribute to class I BPN.[1,3,24] Minimum cervical spine ROM and strength norms for athletic participation at a minimum risk of BPN have not been defined. A variation in the program proposed by Torg[15] is used as a general conditioning component by many collegiate football programs and corresponds to numbers 2 and 3 in the reconditioning protocol.

Equipment considerations seem to offer little assistance in reducing the frequency of injury in other studies.[18,22,23]

Figure 4. Cervical mobilization. A, Flexion, lateral view; B, extension, lateral view; C, left rotation, superior oblique view; D, right rotation, superior oblique view; E, left lateral flexion, superior oblique view; F, right lateral flexion, superior oblique view.

Strength and active and passive ROM capacities of the cervical spine and shoulder girdle may be factors in recurrence.[14] The shoulder pad-helmet interaction during collision may contribute to a combined player-equipment solution, but neck orthoses or neck rolls alone are not the answer, although they must be included in any discussion of reducing or eliminating BPN from football.[26–30]

The reintroduction of the athlete who has completed this program into collision work must be careful. The activities that originally caused the BPN must be introduced gradually, allowing the athlete and the athlete's body time to adapt, which will assist in ensuring minimal risk in the athlete's return. I present this program as 1 methodology for reducing BPN recurrence in college football players. It must be stated, however, that this reconditioning program is empirically derived and may need to be modified by the athletic trainer to comply with the proposed guidelines for safe return to participation.

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REFERENCES

1. Clancy WG Jr, Brand RL, Bergfeld JA. Upper trunk brachial plexus injuries in contact sports. *Am J Sports Med.* 1977;5:209–216.
2. Corley FG. Brachial plexus injury: diagnosis and treatment. Paper presented at: 18th Annual Symposium on Sports Medicine of the University of Texas Health Science Center at San Antonio; January 18, 1991; San Antonio, TX.
3. Speer KP, Bassett FH 3d. The prolonged burner syndrome. *Am J Sports Med.* 1990;18:591–594.
4. Nissen SJ, Laskowski ER, Rizzo TD Jr. Burner syndrome: recognition and rehabilitation. *Physician Sportsmed.* 1996;24(6):57–62,64.
5. Haynes S. Systematic evaluation of brachial plexus injuries. *J Athl Train.* 1993;28:263–267.
6. Torg JS, Reilly PJ. Injuries to the cervical nerve roots and brachial plexus in athletes. *Curr Opin Orthop.* 1994;5:79–84.
7. Markey KL, DiBenedetto M, Curl WW. Upper trunk brachial plexopathy: the stinger syndrome. *Am J Sports Med.* 1993;21:650–655.
8. Sallis RE, Jones K, Knopp W. Burners: offensive strategy for an underreported injury. *Physician Sportsmed.* 1992;20(11):47–55.
9. Hershman EB, Wilbourn AJ, Bergfeld JA. Acute brachial neuropathy in athletes. *Am J Sports Med.* 1989;17:655–659.
10. Cantu RC. Stingers, transient quadriplegia, and cervical spinal stenosis: return to play criteria. *Med Sci Sports Exerc.* 1997;29:S233–S235.
11. Swanik CB, Henry TJ, Lephart SM. Chronic brachial plexopathies and upper extremity proprioception and strength. *J Athl Train.* 1996;31:119–124.
12. Malanga GA. The diagnosis and treatment of cervical radiculopathy. *Med Sci Sports Exerc.* 1997;29:S236–S245.
13. Meyer SA, Schulte KR, Callaghan JJ, et al. Cervical spine stenosis and stingers in collegiate football players. *Am J Sports Med.* 1994;22:158–166.
14. Harrelson GL. Evaluation of brachial plexus injuries. *Sports Med Update.* 1989;4:3–9.
15. Torg JS. Management guidelines for athletic injuries to the cervical spine. *Clin Sports Med.* 1987;6:53–60.
16. Clancy WG. Brachial plexus and upper extremity peripheral nerve injuries. In: Torg J, ed. *Athletic Injuries to the Head, Neck and Face.* Philadelphia, PA: Lea & Febiger; 1982:215–220.
17. Watkins RG. Neck injuries in football players. *Clin Sports Med.* 1986;5:215–222.
18. Levitz CL, Reilly PJ, Torg JS. The pathomechanics of chronic, recurrent cervical nerve root neurapraxia: the chronic burner syndrome. *Am J Sports Med.* 1997;25:73–76.
19. DeLorme TL, Watkins AL. Techniques of progressive resistance exercise. *Arch Phys Med.* 1948;29:263–273.
20. Knight KL. Quadriceps strengthening with the DAPRE technique: case studies with neurological implications. *Med Sci Sports Exerc.* 1985;17:646–650.
21. Smith K. Brachial plexus injuries. Paper presented at: 41st Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 14, 1990; Indianapolis, IN.
22. Maitland GD. *Vertebral Manipulation.* 4th ed. London, England: Butterworths; 1977:168–187.
23. Slagle GW. Securing the neck collar. *Athl Train, JNATA.* 1982;17:175.
24. Jackson DW, Lohr FT. Cervical spine injuries. *Clin Sports Med.* 1986;5:373–386.
25. Andrish JT, Bergfield JA, Romo L. A method for the management of cervical injuries in football: a preliminary report. *Am J Sports Med.* 1977;5:89–92.
26. Chrisman OD, Snook GA, Stantis JM. Lateral-flexion neck injuries in athletic competition. *JAMA.* 1965;192:117–119.
27. Robertson WC Jr, Eichman PL, Clancy WG. Upper trunk brachial plexopathy in football players. *JAMA.* 1979;241:1480–1482.
28. Dix J, Hanna GR. Cervical orthosis for football. *Athl Train, JNATA.* 1985;20:33–34.
29. Fair JD. A one football season injury study on the effectiveness of the cowboy collar. Unpublished report. Oklahoma State University. 1989.
30. Slagle GW. Prevention of neck injuries: the bar roll. *Athl Train, JNATA.* 1983;18:66–67.

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44 Years of "The *Journal*"

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Objective: To review the 44-year history of the *Journal of Athletic Training*.

Description: We examined the 179 issues of the *Journal* and selected 9 years (every 5 years beginning in 1957) for a page-by-page analysis of content. We interviewed 8 former Editors and Editors-in-Chief and drew upon our own experiences during a combined 56 years of association with the *Journal*. The *Journal* has undergone significant changes in both structure and quality; its growth mirrors the growth of the athletic training profession. During its infancy, the *Journal* relied greatly on reprints from other journals. Now, most authors are certified athletic trainers, sharing the results of their own scholarship.

Conclusions: The *Journal*, like the athletic training profession, is alive and strong. It has become an independent leader in the dissemination of athletic health care information.

Key Words: *Journal of Athletic Training*, athletic training, NATA history, editors, scholarship

The athletic training profession and the National Athletic Trainers' Association (NATA) have grown and evolved tremendously during the past 50 years. One instrument of that growth has been "The *Journal*." In this special anniversary article, we will review the history of the *Journal* and hope to show how it both reflects and has been responsible for some of these changes. The *Journal* has gone through numerous changes in the past 44 years, including changes in its mission, organization, structure, name, and content.

44 YEARS OLD

The *Journal of Athletic Training* (*JAT*) is older than it appears. Now in its 34th volume, one would expect that *JAT* is 34 years old. Such is not the case; it is actually 44 years old. The first issue came off the presses in 1956, a proud moment for the 7-year-old NATA. Why the discrepancy? For the first 10 years, there was no volume number. A volume number was first assigned in 1966, and that year's editions were identified as volume 2. So add 10 more candles to the cake.

IN THE BEGINNING

The *Journal* of the NATA was launched in September 1956 with Arthur L. Dickinson, athletic trainer at Arizona State University, as the editor. "Several of us [Board of Directors] talked about it for about a year, then Pinky Newell [Executive Director] came to me and asked me to get it going. Like so many things in the NATA, Pinky was the driver. The *Journal* was just one of many things he did to increase the professionalism of athletic training"(A. L. Dickinson, personal communication, July 1999).

The *Journal* was a 1-man show in the beginning. Dickinson found a local printer in Phoenix to produce the *Journal* and then began collecting material to put into it. "It was like pulling teeth to get material. Athletic trainers were not interested in research or publishing their ideas. So we ended up soliciting information from other journals. . . ." It was tough getting started, but he struggled through. "Pinky never told me it stunk, which it did, but we had a journal" (A. L. Dickinson, personal communication, July 1999).

The 1-man show didn't last long. Tom Hellion joined Dickinson in 1958 as an advertising manager (Table 1). Soon after Jackie Copeland was named Editor (to replace Dickinson), he added Lew Crowl as an Assistant Editor (L. Crowl, personal communication, July 1999) and organized a 5-member Editorial Board, which they called Associate Editors.

WHY THE *JOURNAL*?

In the lead article of the first issue, "Why the *Journal?*"[Editor's note: article follows], Dickinson wrote that the goal of the *Journal* was to educate and share information with members of the athletic environment, both within and outside the NATA, and to make a contribution to the medical professions.[1] He was sure, however, that the "editors of *Life*, *The Journal of the American Medical Association*, and the *Research Quarterly*" would not "sit up until the silly hours of the morning worrying about competition." He then identified 3 specific reasons for having a journal: (1) to exchange ideas and techniques ("A profession that pauses to sit down, may as well lay [*sic*] down, for it is a dead profession"); (2) to disseminate information of professional interest to athletic trainers from a multitude of

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Editor's Note: The authors' combined experience with the *Journal* totals 56 years. Ken Knight began as an abstract writer in 1972 and served as Editor and Editor-in-Chief from 1985 through 1996. Clint Thompson began as an Assistant Editor in 1970 and served as Editor from 1972 through 1984.

Table 1. *Journal* Organization and Timeline

Year	Editor-in-Chief	Other Key ATCs	Editorial Support (non-ATCs)	Affiliation	Comments
1956	Art Dickinson			Arizona State	
1958		Tom Hellion		Northwestern	Associate Editor, responsible for advertising
1959	Jackie Copeland			Wyoming, New York Titans	
1960		Lewis Crowl		Sacramento State	Assistant Editor
		Editorial Board			5 Associate Editors named
1964	D. Conrad Jarvis			Stanford	
		Marvin Roberson		Foothill Junior College	Managing Editor
1966	Marvin Roberson			Brigham Young University	
			Ralph Handy	Chicago, IL	Redactory services, interaction with printer
			Ellis Murphy	Chicago, IL	Advertising Manager
1967		Clyde Stretch		Michigan State	Assistant Editor (new position)
1970		Clyde Stretch		Michigan State	Executive Editor (new position)
		Clint Thompson		Colorado State	Assistant Editor
		Lenwood Paddock		University of Michigan	Associate Editor
1971		Clint Thompson		Colorado State	Associate Editor
		Dennis Aten		Eastern Illinois	Senior Assistant Editor
			Harriett Franklin	Lafayette, IN	Advertising Manager
1972	Clyde Stretch			Columbus, OH	Editor-in-Chief (actually Managing Editor)
		Clint Thompson		Michigan State	Assistant, Associate Editor positions abolished; 4-member *Journal* Committee established
1973	Rod Compton			East Carolina	
1974		Editorial Board			7-member Board added; *Journal* Committee expanded to 8 members
1976			Mary Edgerly	Greenville, NC	Director of Advertising and Circulation, Managing Director, 1977–1985
1977			Barbara Manning	Greenville, NC	Advertising Manager, Circulation Manager (1977), Business Manager and Managing Editor (1981)
1979	Ken Wolfert			Miami, OH	
1983	Steve Yates			Wake Forest	
1985		Don Kaverman		Ferris State	
1986		Editorial Board			Expanded to 15 members
		Departmental Editors			Journal Committee members renamed
	Ken Knight			Indiana State	
1989			Margaret Webb	Richmond, VA	Managing Editor and Redactor
1990	Ken Knight			Indiana State	Editor-in-Chief and Editor positions combined
		Editorial Board			Expanded to 23 members
			Ed Fillmore	Indianapolis, IN	Assistant Editor (copyediting)
1991			Richard Tandy	University of Nevada, Las Vegas	Statistical Consultant
			Janet Brown	Terre Haute, IN	Assistant, then Managing Editor
1993			Graphic Concepts	Rockville, MD	Redactor
			Cadmus Journal Services	Linthicum, MD	Redactor

Table 1. Continued

Year	Editor-in-Chief	Other Key ATCs	Editorial Support (non-ATCs)	Affiliation	Comments
1994		Craig Denegar		Slippery Rock University	5 Associate Editors, selected from Editorial Board, to assist Editor-in-Chief in evaluating peer reviews of manuscripts
		Chris Ingersoll		Indiana State	
		Brent Mangus		University of Nevada, Las Vegas	
		Rich Ray		Hope College	
		Clint Thompson		Northeast Missouri State	
1996	David Perrin			University of Virginia	
			Leslie Neistadt	Hughston Sports Medicine Foundation	Managing Editor
1997		Peggy Houglum		North Shore, IL	Associate Editor
			Bruce Gansneder	University of Virginia	Statistical Consultant
1998		Gary Harrelson		Tuscaloosa, AL	Associate Editor
		Ted Worrell		University of Indianapolis	Associate Editor
		Editorial Board			Expanded to 36 members

sources; and (3) to raise the professional stature of the NATA through written contributions to the medical literature.

The original goals have expanded somewhat as the profession has grown. In 1991, the primary goal was "to expand the profession's body of knowledge and to share this knowledge with members of the profession. A secondary role is to promote internal and external public relations."[2] The earlier practice of reprinting articles from other journals has been replaced with critically analyzing and synthesizing information from other journals in the form of literature reviews. And we have grown to the point that athletic training scientists are now adding to the body of knowledge through original research.

ORGANIZATION AND LEADERS

JAT has had 7 Editors, 6 Editors-in-Chief, and numerous Assistant, Associate, and Managing Editors (Table 1). Duties of that last group have been so diverse and changing that an actual count of the number of people in each position is meaningless.

Until 1990, the Editors-in-Chief were actually Managing Editors, that is, they coordinated the activities of the many department editors (of whom the Editor was one), collected their materials, and put the issue together. "Bobby Barton asked me to replace Rod Compton," recalled Steve Yates. "I didn't know anything about handling a journal and didn't consider myself very scholarly, but I consulted with Pinky Newell, who advised me to take the position" (S. Yates, personal communication, June 1999). Rod Compton, of East Carolina University, and Yates, of Wake Forest University, claim they were asked to serve as Editors-in-Chief "in large part because" (R. Compton, personal communication, July 1999) they lived in North Carolina. Compton recalls that "Otho Davis [Executive Director] said they were moving the *Journal* business office from Lafayette, IN, to Greenville, NC, where the printers were, in order to reduce costs." None of the 3 had served on a Journal Committee before being selected, but each was a great organizer and had a keen business sense and an ability to listen to the *Journal*'s editorial and business staffs and interface with the Board of Directors. Each developed a passion for the *Journal* and can rightly feel pride in the leadership he provided.

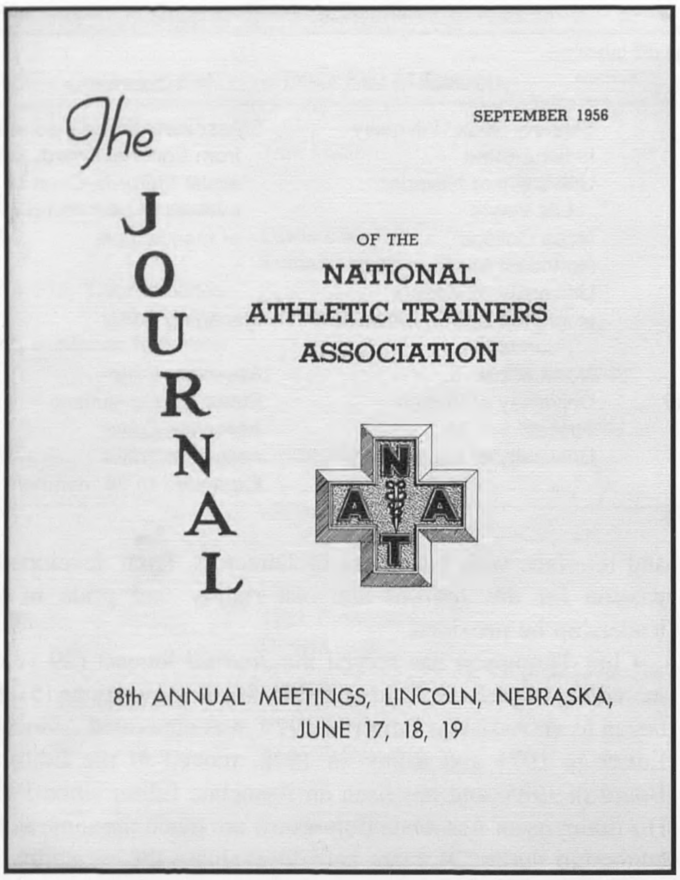
Clint Thompson has served the *Journal* longest (29 years, including 14 years as Editor) and in the most positions (5). He began as an Assistant Editor in 1970, was appointed Associate Editor in 1971 and Editor in 1972, moved to the Editorial Board in 1985, and has been an Associate Editor since 1991. His duties as an Associate Editor now are much the same as his editorship duties 20 years ago: to evaluate the suitability of submitted articles and their peer reviews.

STUDENT AND SUPPORT PERSONNEL

The history of the *Journal* is not complete without mention of the contributions of professionals and graduate students (Table 1). Ralph Hardy, Harriett Franklin, Barbara Manning, and Margaret Webb interacted with printers to lay out the pages of the *Journal*. Janet Brown was the first true Managing Editor, a position now held by Leslie Neistadt. They have been managers of the editorial office and, as such, have handled much of the day-to-day operational responsibility of communicating with authors and printers. Dick Tandy and Bruce Gansneder are statistical consultants to authors, Editors, and the Editorial Board. Their expertise helps to minimize statistical errors in the published manuscripts. And Mary Edgerly, Ron Cunningham, and Teresa Foster Welch of the NATA national office have provided great support by working out business contracts and maintaining mailing lists.

Graduate students were a big part of my (K.L.K.) operation at Indiana State. Before Janet Brown was hired in 1991, graduate students handled all the clerical duties, including more than 7000 pieces of mail in 1990. Without Jane Myers and Katy Rott, my first Editorial Assistants, the 4 boxes of manuscripts and material that I received in 1985 would probably still be packed. My tenure would have been much shorter without the help of the 30+ graduate students who served ably as Editorial Assistants.

A


The
JOURNAL
SEPTEMBER 1956
OF THE
NATIONAL
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ASSOCIATION
N A A T
8th ANNUAL MEETINGS, LINCOLN, NEBRASKA,
JUNE 17, 18, 19

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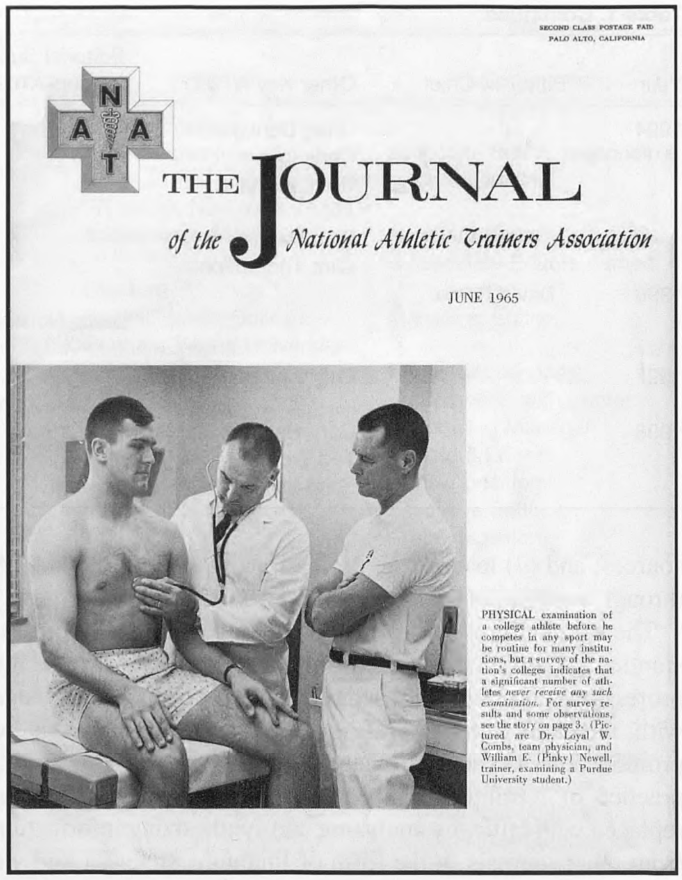
SECOND CLASS POSTAGE PAID
PALO ALTO, CALIFORNIA
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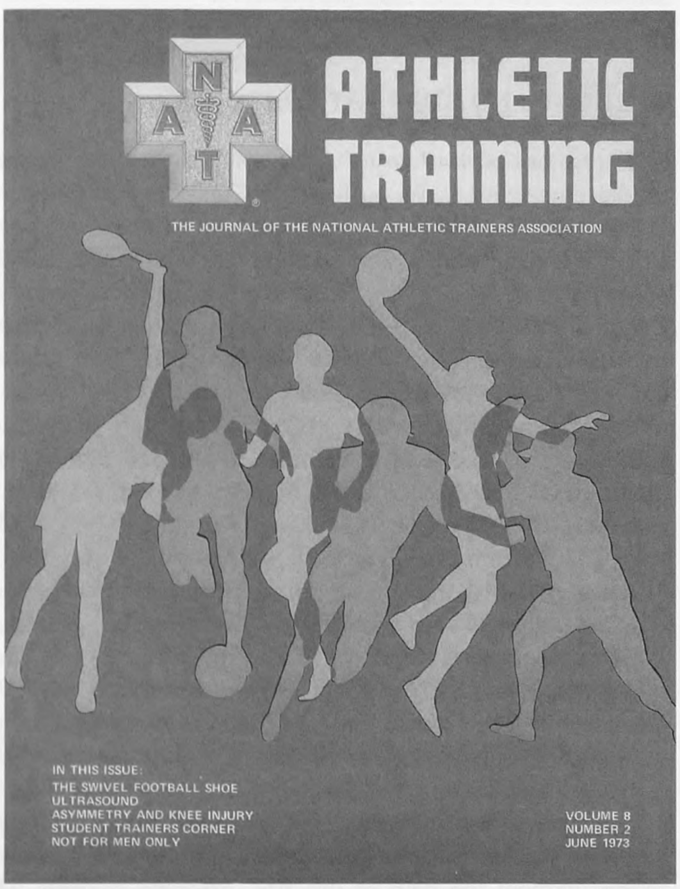
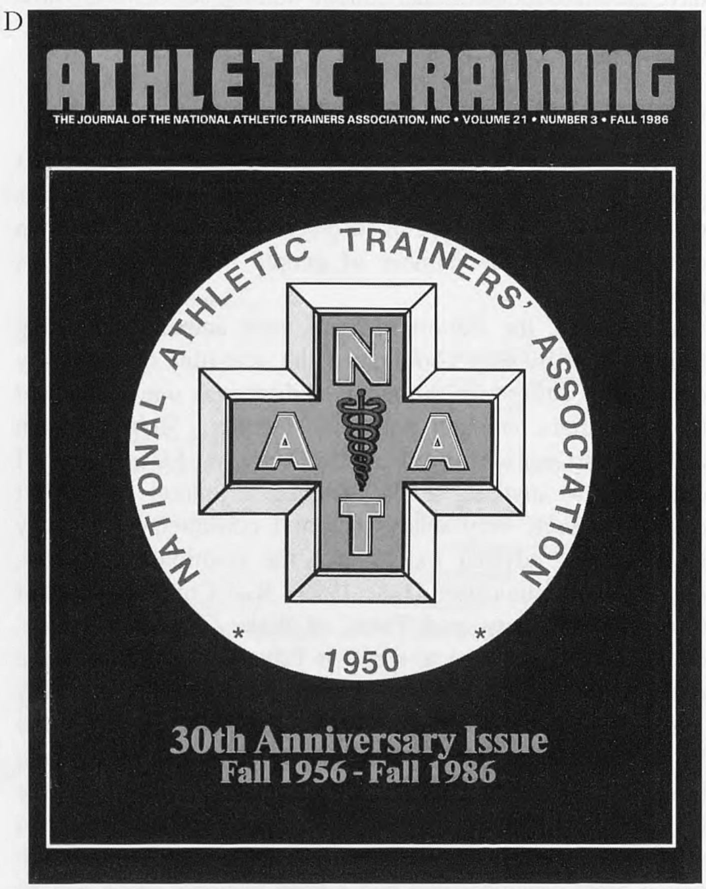
THE JOURNAL
of the National Athletic Trainers Association
JUNE 1965
PHYSICAL examination of a college athlete before he competes in any sport may be routine for many institutions, but a survey of the nation's colleges indicates that a significant number of athletes never receive any such examination. For survey results and some observations, see the story on page 3. (Pictured are Dr. Loyal W. Combs, team physician, and William E. (Pinky) Newell, trainer, examining a Purdue University student.)

C


N A A T
ATHLETIC
TRAINING
THE JOURNAL OF THE NATIONAL ATHLETIC TRAINERS ASSOCIATION
IN THIS ISSUE:
THE SWIVEL FOOTBALL SHOE
ULTRASOUND
ASYMMETRY AND KNEE INJURY
STUDENT TRAINERS CORNER
NOT FOR MEN ONLY
VOLUME 8
NUMBER 2
JUNE 1973

D


ATHLETIC TRAINING
THE JOURNAL OF THE NATIONAL ATHLETIC TRAINERS ASSOCIATION, INC • VOLUME 21 • NUMBER 3 • FALL 1986
NATIONAL ATHLETIC TRAINERS' ASSOCIATION
N A A T
1950
30th Anniversary Issue
Fall 1956 - Fall 1986

All who have benefited from the *JAT* web page (www.nata.org/jat/index.html) appreciate Chris Joyce, a former graduate student at Virginia, for writing and maintaining it. Other former and current Virginia graduate students, including Darin Padua, Randy Schmitz, and Sandy Shultz, assumed the responsibility of writing the questions for the Continuing Education quiz.

MOVIN' ON

Dickinson wasn't the only one to resign from the *Journal* leadership because of a job change. Seven of the 12 former Editors and Editors-in-Chief resigned for similar reasons. Dickinson and Stretch became full-time students, working toward a PhD and PT degree, respectively. Roberson was spending increasing time lecturing in Europe, and Wolfert, Kaverman, and both of us (K.L.K. and C.T.) resigned because we moved to new universities. "My biggest disappointment in working on the *Journal* was having to resign when I changed jobs," stated Wolfert (K. Wolfert, personal communication, June 1999).

ORGANIZATIONAL SUPPORT

Support, or perception of support, from the Board of Directors has been a concern of most *JAT* leaders except Dickinson and Roberson, but they both served on the Board. Dickinson was a member of the Board (District 7) that created the *Journal* and continued to serve during his tenure as Editor. Roberson was on the Board (District 8) during the years he was Assistant Editor, but resigned when he moved to BYU and became Editor.

Compton was disappointed that his support from the Board was inconsistent but was quick to praise the support of Frank George, NATA President (R. Compton, personal communication, June 1999). One of his fondest memories was publishing a cartoon[3] in the Journal, "which brought down the ire of the Board" (R. Compton, personal communication, July 1999). Wolfert, Compton's successor, stated that he couldn't remember a bad experience working with the Board but was disappointed that the Board would not accept some of his proposals (K. Wolfert, personal communication, June 1999).

Two of my (K.L.K.) worst experiences were lack of support for moving Association business to a newsletter (in 1987, subsequently approved in 1990) and the "Black Sunday" incident in 1993.[4] I was invited to Dallas to discuss a Board proposal to move the editorial office from Terre Haute to Dallas in an effort to reduce costs. After arriving there, I was shocked to learn the Board had approved the move 3 months previously. Three hours of "tense" discussion with the Finance Committee followed, and a consultant was hired to study the situation. In June, the Board rescinded its earlier decision and, at the recommendation of the consultant, increased considerably the editorial office budget. But in fairness, we must say there have been many times that various Boards have been quick to act in support of the *Journal*. Many innovations and changes have been heartily supported.

My (C.T.) perspective is that the Board has, at times, been slow to act, but most proposals that it has turned down have eventually been enacted, sometimes by different Boards. It seems that many ideas had to percolate before they were enacted.

For many years, the Board looked to the *Journal* to make money, or at least to break even. The lack of support for some proposals was financially based. One such proposal was "stacking" advertising: the practice of grouping all advertising together at the beginning and end of each issue. Every Editor-in-Chief since Compton (1973) has tried to accomplish this, but these proposals were rejected for fear of losing advertising. Advertisers feel that readers are more likely to read their ads if the ads are next to editorial material. Dave Perrin finally succeeded in 1997.

IDENTITY CRISIS OR GROWTH? 3 NAMES AND 12 COVER DESIGNS

The *Journal* has had 3 different "official" names and a couple of nicknames during its 44 years. It began as *The Journal of the National Athletic Trainers' Association*. In 1972, the name was changed to *Athletic Training, Journal of the National Athletic Trainers Association*,[5] and in 1990, it became the *Journal of Athletic Training*. The first name change followed, and was inspired by, the name change of *The Journal of the American Physical Therapy Association* to *Physical Therapy*. The second name change was inspired by the belief that *Journal of Athletic Training* was more concise and sounded more scholarly and sophisticated than *Athletic Training, Journal of the National Athletic Trainers' Association*.[6]

Yet during many of the past 44 years, the *Journal* has more often been referred to within the Association by its nicknames than by its official names. From the very beginning, it was referred to as "The *Journal*."[7,8] For the first 13 years, "The *Journal*" was in much larger type on the cover than "of the National Athletic Trainers' Association" (Figure). For 5 issues (Winter 1990 through 1991) the *Journal* was referred to as *Athletic Training, JNATA* on the spine and in references. But the name change in 1990 alleviated this need. Presently, "The *Journal*" and "*JAT*" seem to be the common nicknames.

Not surprisingly, the *Journal* cover has been a matter of concern for many editors. Marv Roberson and Con Jarvis felt that changing the cover would help to emphasize the changes they were making in the *Journal* beginning in 1964 (M.

Four covers of the *Journal*. A, The original cover appeared on the first 30 issues. B, In the 3rd design, the title logo appeared at different locations on 16 issues. C, The 7th cover design, which appeared on 50 issues, featured the journal name and NATA logo on the top and a single drawing of sports figures. D, For the 28 issues of the 9th design, the NATA logo was featured in the center of the cover.

Roberson, personal communication, June 1999). They introduced a glossy cover with photographs. Five years later, Roberson changed the emphasis, but not the name, from The *Journal* to *Athletic Training* at the request of the Board of Directors (M. Roberson, personal communication, June 1999). Finding pictures to print on the cover was often a hassle (M. Roberson, personal communication, June 1999) and perhaps the reason that drawings and then standard designs were used by Steve Yates.

The cover of the *Journal* has undergone 12 major changes and an additional minor color change. The longest-lasting cover (1973–1985: 50 issues, see Figure) was followed by the shortest (1985: 2 issues). Four designs lasted only 1 year each (1964–1965, 1969–1970, 1971, and 1974). Others appeared for 12 to 30 issues: 12 (1992–1994), 16 (1965–1969), 20+ (1995-present), 28 (1986–1991), and 30 issues (1956–1964).

Some cover changes resulted from name changes (1969 and 1992) or the change in emphasis from The *Journal* to *Athletic Training* (1969). Other changes have been from photographs to drawings (1971) and from drawings to the NATA logo.

A QUARTERLY PUBLICATION—USUALLY

For most of its 44 years, the *Journal* has been a quarterly publication. Exceptions occurred in 1960 and 1961, when there were only 3 issues (no summer issue), and in 1972, when there were 6 issues. The 6-issue experiment lasted only 1 year, however, and the publication has remained a quarterly since, with a caveat. Beginning in 1995, the *Journal* has teamed with the NATA Research and Education Committee to publish the abstracts of the Annual Meeting in an annual supplement.[9]

A COMPREHENSIVE COMMUNICATION INSTRUMENT

Until 1988, the *Journal* was the sole means of print communication within the NATA.[2] So almost 25% of its content was Association business: committee reports, letters from the President and other officers, minutes of the Board of Directors meetings, certification examination dates, etc (Table 2). The *Journal* had to be all things to all people. Many lively discussions ensued during Journal Committee meetings concerning what belonged in the *Journal*. Some purists felt the *Journal* should contain only educational and clinical material, while others argued that, since the *Journal* was the only publication of the NATA, it should be all things to all people.

Memorial resolutions seemed to be the issue that evoked the most discussion. Most Journal Committee members felt that memorial resolutions, which usually filled a full page,[10] did not belong in a professional journal. But the Board of Directors continued to reject suggestions that they be dropped (K. Wolfert, personal communication, June 1999).[3] A compromise was proposed in 1982 and again in 1987: to separate the *Journal* into 2 publications: a scholarly journal and a newsletter. This solution was approved in 1990.

Table 2. Analysis of the Journal for Selected Years

	1957	1962	1967	1972	1977	1982	1987	1992	1997
Circulation	...	1200	...	2733	6372	8439	11192	17523	22863
Subscription Price ($)	...	1	...	6	7	15	20	32	32
Composition (pages)									
Total*	65	64	78	207	222	313	388	384	448
Journal operations†	0	0	0	11	10½	12	7	18½	30
Articles	28	27	26¼	77	61	99	99	197	223
Advertising*	7¾	2¼	0	67	87	87	147	119	55
Features									
Association information	6	10½	0	37½	35½	85	91	19½	16
Current literature	¾	¼	0	3	4	4	4	6½	8
Medical notes	6	6½	4½	0	8½	6	10	6	0
Other abstracts	0	0	0	10	5	4½	6	7½	35
Book and video reviews	¾	2¾	4	1½	1½	2	3	3½	0
New products	0	½	¼	0	0	1	2	8	7
Letters to the Editor	0	0	2½	0	4	2½	3	5½	0
Annual Meeting Abstracts	0	0	0	0	0	0	5	13½	52
Types of Manuscripts Published									
Total	10	16	10	23	20	45	31	58	49
Tips and techniques	4	3	3	6	7	14	10	10	3
Experimental reports	2	2	6	11	4	4	8	30	29
Literature reviews	1	5	1	6	5	19	10	9	6
Case reports	1	2	0	0	2	7	3	5	7
Comments	2	0	0	0	1	1	0	0	0
Editorials	0	0	0	0	1	0	0	4	4

*Does not include cover, which has 3 pages of advertising per issue, or 12 pages advertising per volume.
†Table of contents, masthead page, index, etc.

THE *NATA NEWS*

The *NATA News*,[11] begun in 1988, was an internal public relations tool, mostly written and edited by John LeGear and David Mooney of Timothy Communications, a Chicago public relations firm hired in 1985 by the NATA to promote the profession. The caution of the NATA leadership over such a publication can be read into LeGear's statement that it was the "first of what we hope will be a continuing series of newsletters. . . . Upon review of the first two issues, the Board of Directors will make the publication schedule."[11]

The intent of the *NATA News* was to "keep NATA members abreast of ever-changing news items."[11] But none of the material that we suggested be moved from the *Journal* was part of the new publication until 1990. In his first meeting with the Journal Committee, Alan Smith, newly appointed NATA Executive Director, agreed. "Association Activities," "Calendar of Events," "Medical Update," and "Memorial Resolutions" were moved to the *NATA News*, and the Journal Committee members responsible for these sections (Earlene Durrant, Jeff Fair, Nina Partin, and Dave Yeo) became *NATA News* contributors.[12]

The impact of this move can be seen in Table 2 (compare 1987 and 1992). Association information decreased from 91 to 20 pages, while articles increased from 99 to 197 pages. The number of articles published increased from 31 to 58. (Although there were 45 articles in 1982, 14 of them were "Tips from the Field," which typically were a single page or less. Articles usually were 3 to 4 pages in length.)

SELF-PUBLISHED

Since the beginning, the *Journal* has been self-published, meaning that the NATA has been its own publisher rather than contracting with a commercial publisher to do the job. This doesn't mean that the NATA has printing presses in the basement of the national office; rather, it means that the NATA organizes, contracts with, and coordinates the efforts of various individuals and firms to produce the *Journal*. This includes establishing an editorial office and supporting its activities, advertising, subscriptions, redactory (copyediting and layout), production (printing, binding, and packaging), and mailing.

Many professional organizations contract with a publisher to handle all aspects of publishing their journal. This is the case, for example, with *Medicine and Science in Sports and Exercise* (American College of Sports Medicine) and the *Journal of Orthopaedic and Sports Physical Therapy* (Orthopaedic and Sports Sections of the American Physical Therapy Association). Each association buys a subscription for each of its members at the regular subscription rate. At the end of the year, the publisher shares the profits with the association.

The greatest, and perhaps only, advantage to self-publishing is financial. Many hassles and headaches are inherent to self-publishing, such as negotiating contracts with each of the vendors, coordinating the efforts of the vendors so that each issue comes together on time, and the fear of receiving suboptimal service from a vendor who gives priority to his or her own publishing projects. But when we investigated this issue in the early 1990s, the cost of commercial publishing would have been about $25 per member per year, whereas the cost of self-publishing was less than $4 per member per year, a substantial savings. And the cost of the *Journal* has always been an issue.

Rod Compton's charge when he was appointed Editor-in-Chief was to bring the costs down. And he did. In fact, he was able to turn a profit when he hired Mary Edgerly to handle advertising (R. Compton, personal communication, July 1999). Ken Wolfert felt that one of his major accomplishments was keeping the *Journal* within budget.

A QUALITY JOURNAL FOR CLINICIANS

Moving Association business from the *Journal* was only part of an effort to make the *Journal* more scholarly. Many interpreted this as meaning a research journal for scholars,[2,13,14] implying that it would not meet the needs of clinicians. Such was never the plan. The goal was always to publish information that helped athletic trainers and other sports medicine clinicians to do their jobs better. Yes, we wanted research, but also reviews of the literature, case studies, and articles about clinical techniques.

Improved scholarship meant improved quality. The improved scholarship we sought was evidenced in articles that were well written and authoritative and in clinical information that was logical, precise, well referenced, and usable. Our dream was that *JAT* become the premier publication of athletic injury prevention, care, and rehabilitation information for clinicians.[13]

A major strategy for increasing the quality of the *Journal* has been to nurture authors. Efforts included publishing articles about how to write scientific and medical articles[15–20] and articles that encouraged athletic trainers to write,[14,21,22] as well as holding writers' workshops at District and Annual Meetings, increasing the quality and quantity of suggestions to authors by peer reviewers and Editors, giving awards for good writing, and, in 1991, adopting the *AMA Manual of Style*[23] as the official "bible" for format and structure. It contains more than 600 pages of rules for writing.

These efforts seem to be working. The percentage of manuscripts published in the *Journal* that are authored by athletic trainers is increasing, and athletic trainers are writing more in other journals. The authors of 4 issues of the *Journal* from 1997–1998 had published more than 600 articles, according to an analysis by Dave Perrin (D. Perrin, personal communication, August 1999).

PEER REVIEW

Peer review is the backbone of any successful professional journal. No editor or group of editors has the breadth and depth of knowledge to judge the acceptability of every manuscript submitted to a journal and to suggest to the authors what they can do to improve the quality of the manuscript. Thus, peer reviewers are essential.

The peer-review process has evolved with the *Journal*. In the beginning, the Editors generally selected the material themselves. In 1960, Lew Crowl was named an Assistant Editor, responsible for helping Jackie Copeland copyedit material (manuscripts and committee reports) (L. Crowl, personal communication, July 1999). In 1963, 5 Associate Editors (the first Editoral Board) were added to help review manuscripts.[24]

Until 1986, the peer-review process was open, meaning that the reviewer knew who the author of the paper was and then signed the review, so the author knew who was making the comments. This process is somewhat intimidating to the reviewer. Will the author interpret the comments as a personal attack? Will the author attempt professional retaliation? There is also the possibility that a reviewer will be influenced (positively or negatively) by knowing the author of the paper.

One of my (K.L.K.) first acts as Editor was to institute a double-blind review process. Some opposed this, feeling that reviewers might hide behind the mask of anonymity and take potshots at the author. But 12 years on the Editorial Board had convinced me that the benefits of the process outweighed the potential problems. And experience bears this out.

Another major change in the peer-review process occurred in 1994, when Craig Denegar, Chris Ingersoll, Brent Mangus, Rich Ray, and Clint Thompson were named Associate Editors. Unlike Associate Editors of the past, these were empowered with decision-making authority. They acted as Editors-in-Chief for the manuscripts assigned to them. Peer reviewers sent their reviews to the Associate Editor, who reviewed them, made a decision concerning the disposition of the manuscript, and then communicated the decision and provided reviews to the author.

The peer-review process evolved in function as well as form. Great efforts have been made to help authors improve their manuscripts, not just to "judge their work." Strategies included holding peer-review workshops for the Editorial Board and Guest Reviewers, encouraging reviewers to communicate with each other, and sharing all the manuscript reviews with each reviewer of a particular manuscript. The result has been improved competence among reviewers, better reviews, and, therefore, better manuscripts. And the effort seems to be appreciated by many authors. One author wrote, "I appreciate the depth of your review. Your people were truly critical—their suggestions indicated a real effort to understand and analyze my manuscript. Most of the other journals I've published in seem to read my material quickly and superficially, make a hasty decision, and move on. They don't give the suggestions you do."[14]

PEER REVIEWERS

In 1963, the *Journal*'s first Editorial Board was organized, although it wasn't actually called an Editorial Board until 1974 (Table 2). The original Board consisted of 5 Associate Editors, including Allan Ryan, MD,[24] who in later years became the founding Editor-in-Chief of *The Physician and Sportsmedicine*.

From 1960 until 1986, the Editorial Board, which fluctuated from 4 to 7 members, handled most of the reviews. Usually manuscripts were sent to every member of the Board. Whew! One year, 2 members of the board reviewed more than 50 manuscripts. Needless to say, there was much turnover on the Editorial Board. The exceptions were Jim Rankin, Bob Moore, and Dan Libera, who each served for more than 20 years.

In 1986, the policy of sending each manuscript to the entire Board was changed, and the Board expanded to 15 members in 1986. It grew to 23 in 1990, 30 in 1995, and the present 36 in 1998. In addition to the Editorial Board, we began using Guest Reviewers: more than 100 in 1996. The difference between Editorial Board members and Guest Reviewers was one of numbers; the former usually reviewed 10 manuscripts per year, the latter up to 4 during my (K.L.K.) reign.

Dave Perrin expanded the interdisciplinary and international representation of the present Editorial Board (D. Perrin, personal communication, August 1999). In addition to athletic trainers with a variety of expertise and experience, the Board includes sport physical therapists, orthopaedic surgeons, primary care and pediatric physicians, and exercise physiologists. Although most Board members are from the United States, also represented are Canada, the United Kingdom, Austria, Israel, and Japan.

PROMOTING SCHOLARSHIP THROUGH WRITING CONTESTS

The *Journal* sponsors 3 writing awards. A Student Writing Contest was announced in 1978,[25] and an award has been given annually since 1979. The Outstanding Research and Non-Research Manuscripts published in the *Journal*, as voted on by the Journal Committee and Editorial Board, have been honored annually since 1989.[26] [Editor's Note: In 1996 and 1997, respectively, these awards were renamed the *Journal of Athletic Training* Clint Thompson Award for the Outstanding Non-Research Manuscript and the *Journal of Athletic Training* Kenneth L. Knight Award for the Outstanding Research Manuscript.]

The Student Writing Contest was instituted to encourage students to develop their writing abilities. Winners are given a cash prize, and the winner and runners-up are given an opportunity to be published. Students are required to write athletic training-related manuscripts and to follow the *Journal*'s Authors' Guide and are encouraged to read a "how to write *Journal* manuscripts" article[16] before preparing their own manuscripts. The winner and runners-up are encouraged to submit their articles for peer review and possible publication.

The Outstanding Manuscript Award winners and 2 runners-up in each category are selected by the Journal Committee and Editorial Board from among the manuscripts published during the previous year.

COUNCIL OF BIOLOGY EDITORS

Since 1991, the Editor-in-Chief has been a member of the Council of Biology Editors (CBE) and attended their annual convention. And Leslie Neistadt, current Managing Editor, was a member of the Council of Biology Editors before being hired by our *Journal*. This has given the *Journal* and the profession exposure within the scientific, technical, and medical journalism communities, as well as providing our Editors an opportunity to converse with other medical editors and learn from their experiences. Two examples of changes that were a direct result of insights gained from CBE were the introduction of structured abstracts and the organization of the table of contents according to type of manuscript, both of which were implemented in the summer of 1996, after 2 years of discussion with CBE colleagues.

INDEXES

Three major types of indexes to professional journals exist: single-volume internal, multiple-volume internal, and external. All 3 usually contain author and subject headings. Internal indexes are those published in the journal itself, and external indexes refer to those, such as MEDLINE, that index thousands of journals. *Journal* single-volume indexing began in 1973 (volume 8) and has continued to the present, except for volumes 18 through 21 (1983–1986).

Two multiple-volume internal indexes were created, in 1981 and 1990. Both of these were cumulative from the beginning of the *Journal*. Normally, the second multiple-volume index would have included only material published since the previous index; however, the first index was a tear-out section in the Spring 1981 issue, and we feared it had been removed from many issues.

The *Journal* is indexed in many fine external indexes, including Focus on Sports Science & Medicine, SPORT Discus, Cumulative Index to Nursing & Allied Health Literature, and Physical Education Index. But the big one, *Index Medicus* (MEDLINE), continues to elude us. Three petitions have been made to the US National Library of Medicine (1982, 1994, and 1998), and 3 times the answer has been "not now." Each of the last 2 petitions resulted in a "recommendation for indexing," but the priority was not high enough for the *Journal* to be included.

Being included in *Index Medicus* seems to have been the subject of more discussion within the Journal Committee and with the Board of Directors than any other topic.

ANNUAL MEETING RESEARCH ABSTRACTS

In 1987, we began publishing the research abstracts for the Annual Meeting.[27,28] Our rationale was that most of the projects were never published, so publishing an abstract at least provided something in the literature for future reference. The 4½ pages (15 abstracts) grew into a 48-page supplement in 1995 and to 96 pages in 1999.

THE PROFESSION IS MUCH OLDER THAN THE NATA

An interesting sidelight to writing this paper was to discover that the ages of the NATA and the profession are very different. Without really thinking about it, we associated the beginning of the profession with the beginning of the NATA in 1950. That would mean the profession, like the NATA, is 50 years old. Such is not the case. In 1958, when the NATA was 9 years old, it presented 25-year awards to 6 members.[29] In 1958, a survey indicated that the average tenure of 83 college athletic trainers was 18.2 years. Three respondents had been athletic trainers for more than 28 years (since before 1930).[30] And what a delight it was to read of Jack Heppinstall's thoughts about his career, which began at Michigan State in 1913.[31]

LABOR OF LOVE—BIG TIME

We share with our predecessors and colleagues who served as Editors and Editors-in-Chief of the *Journal* the feeling that it was a labor of love. Deadlines always loomed. There were never enough good ideas submitted, nor was there adequate time to develop some manuscripts so that they had the impact on the membership we hoped for. And we constantly struggled with time as we attempted to juggle the demands of our "regular jobs" with what was easily a second full-time job with the *Journal*. But none of us regret our involvement. We loved the *Journal* and the many dedicated committee members, peer reviewers, and staff people who assisted us in our labors of love.

THE FUTURE?

The future is alive and well. The *Journal* is mirroring the growth of the profession; it has matured as the profession has matured. Changes in format, quantity and quality of content, and authorship are evidence of this growth. Clinically relevant information is being presented in the *Journal* by certified athletic trainers. The *Journal* and the profession are assuming leadership roles in athletic health care.

ACKNOWLEDGMENTS

Mack Rubley assisted us with analyzing and synthesizing information for the tables. We appreciate his help.

REFERENCES

1. Dickinson AL. Why the *Journal*? *J Natl Athl Train Assoc.* Sept 1956;1.
2. Knight KL. New New New. *Athl Train, JNATA.* 1991;26:104.
3. Cartoon. *Athl Train.* 1978;13:91.
4. Ebel RG. *Far Beyond the Shoe Box: Fifty Years of the National Athletic Trainers' Association.* Dallas, TX: National Athletic Trainers' Association; 1999:45–51.
5. Roberson M. Comment. *Athl Train.* Spring 1972;7:1.
6. Knight KL. Report to the NATA Board of Directors. Denver, CO. Feb 1991.

7. Linskey B. Convention Notes of August 1956. *J Natl Athl Train Assoc.* Sept 1956:9–11.
8. Dickinson AL. Masthead. *J Natl Athl Train Assoc.* Jan 1957;2.
9. Knight KL. Professional growth and maturity. *J Athl Train.* 1995;30:101.
10. In Memoriam. *Athl Train, JNATA.* 1989;24:388–392.
11. LeGear J, Mooney D. To our readers. *NATA News.* 1988;1:3.
12. Webb M, ed. *NATA News.* 1990;2:6, 13–16.
13. Knight KL. Expanding our body of knowledge. *Athl Train.* 1990;25:8.
14. Knight KL. A journal for clinicians. *J Athl Train.* 1992;27:5.
15. Knight KL. Preparation of manuscripts for publication. *Athl Train.* 1976;11:127–129.
16. Knight KL. Writing articles for the *Journal*. *Athl Train.* 1978;13:196–198.
17. Knight KL. Tips for scientific/medical writers. *Athl Train.* 1990;25:47–50.
18. Knight KL. Use of first person in scientific writing. *Athl Train.* 1990;25: 310.
19. Knight KL, Ingersoll CD. Structure of a scholarly manuscript: 66 tips for what goes where. *J Athl Train.* 1996;31:201–206.
20. Knight KL, Ingersoll CD. Optimizing scholarly communications: 30 tips for writing clearly. *J Athl Train.* 1996;31:209–213.
21. Knight KL. Research in athletic training: a frill or a necessity? *Athl Train.* 1988;23:215.
22. Knight KL, Ingersoll CD. Developing scholarship in athletic training. *J Athl Train.* 1998;33:271–274.
23. American Medical Association. *American Medical Association Manual of Style: A Guide for Authors and Editors*. 9th ed. Baltimore, MD: Williams & Wilkins: 1998.
24. The secretaries' report. *J Natl Athl Train Assoc.* August 1963;3.
25. Knight KL. First annual NATA Student Writing Contest. *Athl Train.* 1979;13:127.
26. Outstanding Manuscript Awards. *J Athl Train.* 1994;29:282–284.
27. Abstracts of the 1987 National Convention Free Communications papers. *Athl Train.* 1987;22:106–110.
28. Knight KL. Free communication and knowledge growth. *Athl Train.* 1987;22:144.
29. Secretaries' report. *J Natl Athl Train Assoc.* October 1958;1.
30. Christmas E. How they answered. *J Natl Athl Train Assoc.* September 1956;6–8.
31. Heppinstall retires after 45 years as head trainer. *J Natl Athl Train Assoc.* January 1959;2.

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www.nata.org/jat

Why the *Journal*?

Arthur L. Dickinson

Arizona State University, Tempe, AZ

With this writing, the *Journal of the National Athletic Trainers' Association* begins what is hoped will be a publication offering service to its organization, education and information to other members of the athletic environment, and a contribution to the medical professions. It is not brought forth with the idea of shaking the journalistic world to its very foundations. The editors of *Life, The Journal of the American Medical Association*, and the *Research Quarterly* will not sit up until the silly hours of the morning worrying about competition. It will not even be a source of income to the profession. Is there, then, a need for such a publication? Definitely, yes!

First, there is a need for an exchange of ideas and techniques. A profession that pauses to sit down may as well lay down, for it is a dead profession. Through the *Journal*, research and invention from one athletic trainer can be made known to the entire membership, and the growth of professional knowledge will directly benefit the most important product in America—her young men.

Second, the *Journal* will be able to disseminate information of professional interest to the athletic trainer from a multitude of sources. For example, a study of heavy resistance exercise at the University of Iowa can benefit the athlete in Florida or Oregon.

Third, the professional stature of the organization can be raised through written contributions by every member; along with the value of this material to himself and his fellow members, it can help to inform the public and the professions we are allied with of the importance of athletic training. We owe it to ourselves and to the coming generation of men to grow enough to insure proper and adequate care for the health and safety of everyone who chooses to participate in high school, college, or professional athletics.

This is why we need the *Journal*.

Editor's note: This article is reprinted from the *Journal of the National Athletic Trainers' Association* (1956, volume 1, number 1).

Media Reviews

Books
Functional Movement in Orthopaedic and Sports Physical Therapy
Bruce Brownstein and Shaw Bronner, Editors
Worksite Health Promotion
David H. Chenoweth
Clinical Experiences in Athletic Training: A Modular Approach, 2nd edition
Kenneth L. Knight

Functional Movement in Orthopaedic and Sports Physical Therapy
Editors: Bruce Brownstein and Shaw Bronner
Churchill Livingstone, Inc, New York, NY
1997
375 pages
ISBN: 0-443-07530-1
Price: $59.95

Any professional involved in the evaluation, rehabilitation, and conditioning of athletes should find *Functional Movement in Orthopaedic and Sports Physical Therapy* a valuable resource. As its primary focus, this text introduces an integrated approach to movement and function by explaining the underlying principles of movement, the measurement of function, the treatment and evaluation of losses in movement and function, and the special aspects of movement in unique populations. In fulfilling this purpose, the text comprehensively covers a variety of topics related to biomechanics, motor control, neuroscience, outcomes research, injury evaluation, therapeutic exercise, and functional movement and performance. Overall, the authors have done an outstanding job of integrating the information from these various topics into a text that is concise and easy to follow.

Functional Movement in Orthopaedic and Sports Physical Therapy is organized into 4 major sections. Section I provides an integrated, in-depth review of the relationships among the fields of biomechanics, motor control, and neuroscience with the clinical aspects of functional movement, evaluation, and rehabilitation. Chapter 1 is an introduction to the interaction of movement biomechanics and motor control. The authors present several theories on motor control and debate the ability of these theories to adequately explain the control of functional movement. Chapter 2 explores the role of various mechanoreceptors in functional movement and rehabilitation through a discussion of articular neurology, proprioception, and neuromuscular function.

Section II provides an excellent, much-needed discussion on the overlooked topics of outcomes research and measures of functional movement. The authors discuss several aspects related to outcomes research: the growing importance of outcomes research; the conceptual basis for measuring outcomes; the factors that are at issue in measuring function and performance; and the different methods for measuring performance in sports medicine. Chapter 3 provides valuable information for clinicians interested in effective outcomes research.

The evaluation and rehabilitation concepts presented in Section III, chapters 4–6, provide information related to the shoulder, lumbo-pelvis region, and lower extremities. These chapters provide an integrated approach to the evaluation and rehabilitation process, by examining the roles of biomechanics, motor control, and neuroscience in relation to postural deviations, muscular imbalances, and functional rehabilitation.

Section IV addresses special aspects of function and movement in the athletic, dance, and geriatric populations. A study of these specific groups provides the reader with a better understanding of the characteristic qualities of movement within each group.

Functional Movement in Orthopaedic and Sports Physical Therapy is an excellent clinical reference for the certified athletic trainer and physical therapist. This text is a valuable reference for the professional specifically interested in the integration of biomechanics, motor control, neuroscience, and functional performance-related issues within the injury evaluation and rehabilitation processes. Studying this holistic approach to evaluation and rehabilitation should enhance the reader's clinical skills and reasoning ability. Each chapter contains an extensive list of both current and classic references, a feature that is extremely useful to readers who are interested in pursuing a deeper understanding of these topics.

Because this text is based upon the integration of several advanced bodies of knowledge related to the evaluation and rehabilitation process, it is not well suited for use as an instructional text for undergraduate students. Since chapters 1 and 2 contain advanced material, readers need a basic knowledge of biomechanics, motor control, and the neurosciences in order to fully comprehend the information. However, this text would serve as an excellent reference in advanced-level rehabilitation courses.

In summary, this text is an excellent reference on evaluation and rehabilitation of orthopaedic and sports-related injuries. The authors have successfully integrated the basics of biomechanics, motor control, and the neurosciences with the clinical reasoning and decision-making processes of evaluation and rehabilitation. The cost of the text is $59.95, which I consider reasonable, considering the valuable information that is provided.

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Worksite Health Promotion
David H. Chenoweth
Human Kinetics, Champaign, IL
1998
200 pages
ISBN: 0-88011-542-4
Price: $34.00

To prepare athletic training students for the wide variety of potential jobs available to them, it is important to include teaching and experiences in non-traditional settings. This book, *Worksite Health Promotion*, contains valuable information for students. It could be used in an administration class, one on health promotion, or one dealing with clinical and industrial needs. With the material included and the modest price, it should be on the library shelves of both institutions and curriculum professionals. It has already helped 2 of my Health Promotion and Wellness majors find valuable information and resources.

The book provides the author's guide to the entire spectrum of a worksite health promotion program. He includes preprogram needs assessment and funding sources, building, presenting the specific proposal, implementation, motivation, marketing, and assessment. Model programs already in operation are highlighted, as are adaptations for small and multisite businesses. Suggestions for coursework, certifications, and forms are presented as well.

The writing and explanations of the major aspects of worksite health promotion are understandable by undergraduates. In addition to applying basic principles to the corporate setting, the book lists important groups and organizations involved in worksite health promotion. Finding appropriate associations, journals, and certifications in 1 place is appealing for students and athletic trainers looking to add to their marketability. However, neither the NATA nor the Clinical/Industrial/Corporate Athletic Trainers' Committee is listed. The lack of e-mail addresses for most of the groups is a glaring deficiency as the country moves more and more to cyberspace connections. The inclusion of these links would help the book become a more useful tool, but the information may change and, therefore, date the book earlier than the basic program information would warrant.

Improvements to the book might include more explanation of the graphs outside the body of the text and a better organization of material. The book starts with the need for worksite programs, moves into setting up programs and problems to watch out for in programs, and then returns to the initial information. Better flow between sections or a different order might help the reader. If used as a text, the book's summary sections could be expanded, vocabulary introduced in each chapter defined, and additional questions provided to aid in more useful application.

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Clinical Experiences in Athletic Training: A Modular Approach
Kenneth L. Knight
Human Kinetics, Champaign, IL
1998
2nd edition
160 pages
ISBN: 0-88011-723-3
Price: $24.00

With this text, the author has addressed an important and valid issue in current athletic training clinical education: that learning psychomotor skills by "osmosis" or by just putting in time is ineffective. The author's intention, in this second-edition text, is to refine his approach to athletic training clinical education systems. Although this manual is a positive step toward organizing and structuring clinical education, it leaves room for improvement.

The result of this effort is the grouping of individual skills or competencies into 82 modules, organized into 17 groups and 5 levels. The skills or competencies were taken from the National Athletic Trainers' Association (NATA) Board of Certification's list of psychomotor skills required for entry-level athletic trainers. Each module is arranged so that the student begins by developing simple skills before more complex ones. The module also requires the student to demonstrate mastery of each clinical skill. The objectives and competencies presented for each module are followed by relevant references. Grades for skill performance of each competency can then be listed.

At the present time, the NATA's Education Task Force on Clinical Education has presented its reform for psychomotor skills, and its revisions should be used in this manual. The revisions contain specific outcome objectives required of the entry-level athletic trainer, which are not used in this manual. Modules on injury management (evaluation) of specific joints require the student to determine the normalcy of ligaments and muscles, but do not indicate the use of any "special tests" as part of the process. The objectives listed in the manual are general or vague, maybe designed as such to allow for easier adaptation by consumers, but the possibility for conflict exists due to differences in interpretation.

Feedback on performance is critical in the student's skill development and needs to be more of a focus in the manual. The modules allow the evaluator to grade the student's performance and provide brief comments. No instructions or directions are given in the manual with regard to what system should be used in grading student performance: A-F, pass-fail, etc. The student would benefit more by knowing why he or she failed a skill or received a C for performance. The comment area could be used for this purpose, but often the allocated space is too small and would discourage the evaluator from providing all the pertinent feedback.

The author suggests that proficiency of each skill can be taught and evaluated by peers. Although this process does have merit and can reinforce learning in the more advanced student, improper skills can be passed to the less advanced student. The new education reforms require direct supervision of students by certified athletic trainers, and, therefore, the concept of peer teaching may be inappropriate in the manual.

The issue of organizing and giving structure to athletic training clinical education is advanced and complex, and this manual by Dr. Knight offers a method of approach. In the present form, the manual can be interpreted as a compilation of checklists, which can assist in documenting student performance. Along with the revisions suggested, the development of an instructional text to accompany this evaluation manual would be of great benefit.

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REQUEST FOR PROPOSALS

Athletic Training Outcomes Assessment

Background

Historically, physicians – particularly orthopedic surgeons – have used injury-specific, objective evaluation systems to assess the results of their treatment and to evaluate patient function, e.g., International Knee Documentation Committee (IKDC) evaluation form, the American Shoulder and Elbow Surgeons' Shoulder evaluation form. In the last decade, generic measures of the patient's assessment of his or her behavioral functioning, subjective sense of well-being and perception of health have been developed and used to assess the health status of patients with general and chronic diseases, e.g., SF-36. These evaluative tools inquire about the patient's vitality, level of general and mental health and levels of physical and social functioning following illness or injury.

The responsibility for treatment and rehabilitation of musculoskeletal injuries among the physically active is shared by a growing number of allied health practitioners. Certified athletic trainers are well positioned in clinics and hospitals, secondary schools, colleges and universities and industrial settings to provide needed physical medicine services to these patients. Outcomes of treatment in athletic training and sports medicine include but are not limited to:

(a) patient assessment of a particular treatment intended to eliminate his/her specific physical impairment;

(b) patient-reported evaluation of function and functional limitations experienced during activities of daily living, work, sport and/or recreational activity;

(c) patient assessment of his/her ability to perform sport, recreational or work at pre-injury activity levels.

Studies are needed to evaluate the utilization of health care resources, e.g., the number of visits the patient made to the certified athletic trainer, the equipment and/or supplies issued to the patient in the course of treatment. Of similar importance is the level of satisfaction the patient has with the caregiver and/or the support staff and with the overall results of treatment.

Outcomes research is needed in athletic training and sports medicine to determine the effectiveness of a particular intervention, treatment methodology or rehabilitation protocol for sports-related injuries. Moreover, outcomes research is needed to validate the quality of care provided by certified athletic trainers in comparison with reported patients' evaluations of their outcomes for treatment provided by physiatrists; board-certified physical therapists, specifically specialists compared with non-specialists; physical therapist assistants; and /or non-licensed clinical staff members.

Where and When to Apply

The NATA Research and Education Foundation, through its Research Committee, is acting as gatekeeper for the database from the nationwide 1996-1998 Athletic Training Outcomes Assessment. Preliminary reports from the Outcomes Assessment have been published at regular intervals in the monthly newsletter of the National Athletic Trainers' Association, *NATA News*. Now available for further analysis is the raw data from more than 6,000 patients who received 90 percent or more of their care from certified athletic trainers. These outcomes data were collected at numerous venues throughout the United States, including sports medicine clinics, high schools, colleges, universities and industrial settings.

Access to the 1996-1998 Athletic Training Outcomes Assessment database will be limited to principal investigators who have submitted research proposals approved and funded by the NATA Research and Education Foundation. The Foundation accepts grant proposals in two funding cycles per year, March 1 and September 1, with notification in July and January, respectively.

Procedure

To receive a copy of the Research Grant Application, write to the NATA Research and Education Foundation; 2952 Stemmons; Dallas, TX 75247; call 800-TRY-NATA, ext. 121; or e-mail <barbaran@nata.org>. ■

2000 Request for Proposals

The NATA Research & Education Foundation is pleased to announce that $120,000 is available in 2000 for Grant Awards. Priority consideration will be given to proposals which include a certified athletic trainer as an integral member of the research or project team.

Research Grants

No. of Awards:	Multiple awards are available
Available:	$115,000 total, no minimum or maximum dollar amounts for individual grants
Deadlines:	March 1 and September 1
Notification:	July and February

I. General Grants

The Foundation will fund a number of studies which address important issues in five categories: basic science, clinical studies, sports injury epidemiology, observational studies and educational studies.

II. Pediatric Sports Health Care

The Foundation encourages research studies that will have clinical relevance to the development of the pediatric athlete, and the prevention, treatment and rehabilitation of injuries sustained by the physically active pediatric participant. A great need exists for epidemiologic studies to determine pediatric injury patterns and specific populations at risk.

Background

Very little experimental evidence concerns the impact of physical activity upon the general development of the child. The recent, tremendous growth of children's participation in organized sport has outpaced efforts to clearly understand the consequences of intense physical activity on the developing young adult. The incidence of organized sports participation by preadolescents and adolescents has increased dramatically in the past two decades. Children represent the largest group of individuals engaging in organized sport in this country. However, little is known about the incidence and severity of injuries associated with child or adolescent participation in these activities.

Furthermore, the number of children and adolescents participating in sport increases regularly from year to year. Despite this increase, the President's Council on Physical Fitness has determined that the fitness levels of young adults in this country are on the decline and urges regular participation in sport and exercise by a much higher percentage of the childhood population.

It is assumed that exercise and sports participation have positive effects on children, and there is increasing evidence that regular exercise is important to their physical and psychological well-being. The United States Department of Health and Human Services in its compendium on National Health Promotion and Disease Prevention Objectives recommends significant increases in daily physical activity for children to combat problematic sedentary lifestyles and obesity among young adults. Many experts believe that lifestyles leading to adult heart disease often begin in childhood and that habitual physical activity during development may play an important role in slowing the progression of cardiovascular disease, particularly in high-risk children. Moreover, the increasing awareness and interest in exercise as a treatment medium by the medical community has undoubtedly influenced parents' perceptions of the importance of regular physical activity in the lives of their children.

Yet, participation in sport does pose risks. Exercise is a human stressor which results in bodily adaptations that can have beneficial or adverse effects on health. Childhood and adolescence as developmental periods, introduce variables that are not found in the adult athlete. Asynchronous rates of development among similarly-aged children present difficult challenges to those who teach and supervise the physical activity of young athletes. Attempts to develop training programs for the young athlete pose a dilemma that the exercise science and medical professions have yet to resolve satisfactorily. A developing child differs significantly in anatomical and physiological parameters from the mature adult. These differences must be taken into account when prescribing exercise programs for young athletes. Children in the 8-15 year age group are in a complicated and critical growing period. Muscular development also varies considerably and the actual strength of muscle relates to the stresses that can be placed on the skeletal framework without injury. If children and adolescents are involved in organized sports, it is obvious that a considerable amount of skeletal growth is occurring simultaneously with periods of intense physical activity.

The repetitive microtrauma and overuse syndromes associated with sports, and their development in children's growth plates have been widely debated. Traumatic sports injuries to the growth plate do occur and the potential for a growth disturbance is always a concern of parents and physicians. While the growth plate seems relatively immune to damage from overuse, it remains to be seen if this sensitive area of children's anatomy remains protected from the increasingly rigorous training to which young athletes are subjected.

Objectives

The Research and Education Foundation, therefore, encourages high quality research proposals that will help establish a firm scientific foundation for basic and applied programs in pediatric sports health care. Areas of interest may include but are not limited to: epidemiology of athletic injuries in children and adolescents; the role of pre-participation physical examination in the identification of injury risk factors among children and adolescents; the efficacy of specific safety equipment in preventing or reducing the incidence and severity of injury; injury mechanisms and exercise pathophysiology in children; prevention, treatment and rehabilitation of pediatric athletic injuries; conditioning of the child athlete; and musculoskeletal healing processes in children. Given the present funding available, it is expected that grant proposals emphasizing local and regional epidemiological approaches will initially be submitted with the intent to develop data bases and model approaches to injury surveillance which can lead to future large scale epidemiologic or intervention studies on a national level.

Applicants must be current certified member of the NATA.

III. Doctoral Research Grants

No. of Awards:	Two
Available:	$2,500 for each grant
Application Deadline:	March 1
Notification:	April 15
Sponsor:	Active Ankle Systems

You must be a doctoral student at the institution where the research is to be performed and have doctoral student status during the term of the grant to be considered for funding.

Application Procedure

To receive a copy of the Grant Application or the Doctoral Research Grant Application, please write to NATA Research & Education Foundation, 2952 Stemmons, Dallas, TX 75247, e-mail the request to BarbaraN@nata.org or call 800-TRY-NATA ext. 121. ■

Research Grant Program Pre-Proposal Submission

The NATA Foundation now requires that investigators interested in submitting a grant application to the NATA Foundation first submit a "Pre-proposal". The purpose of the Pre-proposal is to optimize the time invested by both the NATA Foundation Research Committee and the investigators in grant proposals submitted to the NATA Foundation. The Pre-proposal will allow the NATA Foundation Research Committee to evaluate whether or not the proposed research project is of interest to the NATA Foundation. The NATA Foundation Research Committee will evaluate the Pre-proposal both for subject matter (topic and hypotheses) and for research design/methodology. Based upon this evaluation, the committee will then either invite the submission of a full proposal or indicate that the proposed project is not of interest to the NATA Foundation. An invitation to submit a full proposal does not imply a commitment to funding. It does indicate that the topic is of potential interest to the NATA Foundation and that the general research design seems reasonable based on the information given in the Pre-proposal. A commitment to funding may occur only after a detailed review of the full proposal by the NATA Foundation Research Committee.

Instructions for Submission

The Pre-proposal is limited to 2 pages, single-spaced. This space limitation requires that the principal investigator be explicit and concise in providing the following information:

1. Name, Credentials, Address, Sponsoring Institution, Title of Proposal
2. Statement of the Problem. This section should contain a brief statement of the problem and should state explicitly how the project relates to athletic training and/or the healthcare of the physically active.
3. Specific Aims and Hypotheses. This section should present the specific questions to be addressed and the specific hypotheses that will be tested in the project. It is often helpful to present numbered specific aims accompanied by the associated hypotheses.
4. Experimental Design and General Methods. This section should contain a general outline of the research design of the proposed study, and should indicate what methods will be used to collect key data. There is no need to provide detailed descriptions of the methods.

Mail the completed Pre-proposal to:

Michael R. Sitler, EdD, ATC, Chair, NATA Foundation Research Committee, Department of Kinesiology, 114 Pearson Hall,Temple University,Philadelphia, PA 19122

N A T A

RESEARCH & EDUCATION FOUNDATION

REQUEST FOR PROPOSALS

National High School Injury Surveillance Study Data

Introduction

The National Athletic Trainers' Association Research and Education Foundation is acting as gatekeeper of the data recorded through an NATA-funded, three-year, nationwide high school injury surveillance study. These data, collected for 10 sports during the 1995-96, 1996-97 and 1997-98 sports seasons, describe the rate and type of injuries suffered by athletes at the high school level. The data from this epidemiological study could be used to help pinpoint causes of injuries as well as means for prevention, and the Foundation's Research Committee is seeking proposals for research projects that utilize this unique injury data base. Data from this exclusive NATA high school injury surveillance study could be used to identify high-risk activities and/or situations, such as practices versus competitions. Findings could, in turn, be applied to injury prevention efforts or be used to enhance the safety of student athletes' participation in high school sports.

Background

Each year, an estimated six million high school students participate in interscholastic sports in the United States. Few studies exist currently that address the real safety risks to the adolescents involved in such endeavors. The current NATA study is an extension of a previous three-year high school injury research effort undertaken by the NATA in 1986, which provided a benchmark for high school injury rates and severity in the United States.

The 1995-1998 NATA high school injury surveillance study tracked injuries that occurred in football, boys' and girls' basketball, baseball, softball, volleyball, wrestling, boys' and girls' soccer and field hockey. A cross-section of high schools from 45 states – including private and public schools from rural and metropolitan areas of the country – participated in the study, with certified athletic trainers acting as the primary record keepers. More than 235 secondary schools were affiliated with this research project, collectively submitting epidemiological data and injury records for nearly 76,000 high school athletes.

Objectives

The Research and Education Foundation advocates top-caliber research proposals that will use the national high school injury data in a constructive and enlightening manner to help attain the goal of utmost safety for all student athletes. To this end, the Research and Education Foundation offers access to the NATA High School Injury Surveillance data base to investigators studying safety risks in pediatric and adolescent sports participation. The Foundation seeks proposals that can effectively utilize the data base to initiate new studies or support existing research in this area.

Procedure

Access to the data will be limited to principal investigators. Deadlines for proposals to access the NATA High School Injury Surveillance data base are March 1 and September 1. To receive an application for this RFP, please write to the NATA Research and Education Foundation; 2952 Stemmons; Dallas, TX 75247; call 800-TRY-NATA, ext. 121; or e-mail <barbaran@nata.org>. ■

NATA

RESEARCH & EDUCATION FOUNDATION

REQUEST FOR PROPOSALS

Introduction

The NATA Research and Education Foundation announces that $250,000 is available to support research on pediatric sports health care. The primary goal is to encourage epidemiological study that will have clinical relevance to the development of the pediatric athlete and the prevention, treatment and rehabilitation of injuries sustained by the physically active pediatric participant.

Background

The incidence of sports participation by preadolescents and adolescents has increased dramatically in the past two decades. It is estimated that more than 30 million children and adolescents are participating in organized sports in the United States. Consequently, they represent the largest group of individuals engaging in such activities in this country. However, this recent growth of children's participation in sport has outpaced efforts to clearly understand the consequences of intense physical activity on the development of young adults.

It is assumed that exercise and sports participation have positive effects on children, and increasing evidence shows regular exercise is important to their physical and psychological well-being. Yet, participation in sport does pose risks. Increasing sports specialization at younger and younger ages has placed a high premium for athletic success. However, little is known about the incidence and severity of injuries associated with child or adolescent participation in these activities. Therefore, a great need exists for epidemiological studies to determine pediatric injury patterns and specific populations at risk. Furthermore, types of intervention strategies to reduce the incidence and severity of pediatric injuries in sport need to be developed as well as the measures of their effectiveness.

Objectives

The Research and Education Foundation, therefore, encourages high quality research proposals emphasizing the epidemiology of athletic injuries in children and adolescents, which will help establish a firm scientific foundation for basic and applied programs in pediatric sports health care.

Procedure

To receive a copy of the Research Grant Application, contact:

NATA Research and Education Foundation
2952 Stemmons
Dallas, TX 75247
phone (800) TRY-NATA, ext.121
fax (214) 637-2206
e-mail <barbaran@nata.org> ■

CEU Quiz

The CEU quiz for the December 1999 issue (Volume 34, Number 4) of the *Journal of Athletic Training* will be located in the January 2000 *NATA News*.

22[ND] Annual Student Writing Contest

Entries must be received at the following address by March 1, 2000:

NATA Student Writing Contest
Deloss Brubaker, EdD, ATC
Life College
1269 Barclay Circle
Marietta, GA 30060

For a detailed description of the contest rules, please refer to the September 1999 issue of the *Journal of Athletic Training*.

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(Revised January 1999)

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11. Each page must be printed on 1 side of 8½-by-11-inch paper, double spaced, with 1-inch margins in a font no smaller than 10 points. Each page should include line counts to facilitate the review process. Do not right justify pages.
12. Manuscripts should contain the following, organized in the order listed below, with each section beginning on a separate page:
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    f. Tables (each on a separate page)
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    h. Figures
13. Begin numbering the pages of your manuscript with the abstract page as #1; then, consecutively number all successive pages.
14. Units of measurement shall be recorded as SI units, as specified in the *AMA Manual of Style*, except for angular displacement, which should be measured in degrees rather than radians. Examples include mass in kilograms (kg), height in centimeters (cm), velocity in meters per second ($m{\cdot}s^{-1}$ or m/s), angular velocity in degrees per second ($°{\cdot}s^{-1}$), force in Newtons (N), and complex rates (mL/kg per minute).
15. Titles should be brief within descriptive limits (a 16-word maximum is recommended). If a disability is the relevant factor in an article, the name of the disability should be included in the title. If a technique is the principal reason for the report, it should be in the title. Often both should appear.
16. The title page should also include the name, title, and affiliation of each author, and the name, address, phone number, fax number, and E-mail address of the author to whom correspondence is to be directed.
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19. The body or main part of the manuscript varies according to the type of article (examples follow); however, the body should include a discussion section in which the importance of the material presented is addressed and related to other pertinent literature. Liberal use of headings and subheadings, charts, graphs, and figures is recommended.
    a. The body of an **Original Research** article consists of a methods section, a presentation of the results, and a discussion of the results. The methods section should contain sufficient detail concerning the methods, procedures, and apparatus employed so that others can reproduce the results. The results should be summarized using descriptive and inferential statistics and a few well-planned and carefully constructed illustrations.
    b. The body of a **Literature Review** article should be organized into subsections in which related thoughts of others are presented, summarized, and referenced. Each subsection should have a heading and brief summary, possibly one sentence. Sections must be arranged so that they progressively focus on the problem or question posed in the introduction.
    c. The body of a **Case Report** should include the following components: personal data (age, sex, race, marital status, and occupation when relevant—but not name), chief

Authors' Guide

complaint, history of present complaint (including symptoms), results of physical examination (example: "Physical findings relevant to the rehabilitation program were . . ."), medical history (surgery, laboratory results, examination, etc), diagnosis, treatment and clinical course (rehabilitation until and after return to competition), criteria for return to competition, and deviation from expectations (what makes this case unique).

d. The body of a **Clinical Techniques** article should include both the *how* and *why* of the technique: a step-by-step explanation of how to perform the technique, supplemented by photographs or illustrations, and an explanation of why the technique should be used. The discussion concerning the *why* of the technique should review similar techniques, point out how the new technique differs, and explain the advantages and disadvantages of the technique in comparison with other techniques.

Percentages should be accompanied by the numbers used to calculate them.

20. **Communications** articles, including official Position Statements and Policy Statements from the NATA Pronouncements Committee; technical notes on such topics as research design and statistics; and articles on other professional issues of interest to the readership are solicited by the *Journal*. An author who has a suggestion for such a paper is advised to contact the Editorial Office for instructions.
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22. References should be numbered consecutively, using superscripted arabic numerals, in the order in which they are cited in the text. References should be used liberally. It is unethical to present others' ideas as your own. Also, use references so that readers who desire further information on the topic can benefit from your scholarship.
23. References to articles or books, published or accepted for publication, or to papers presented at professional meetings are listed in numerical order at the end of the manuscript. Journal title abbreviations conform to *Index Medicus* style. Examples of references are illustrated below. See the *AMA Manual of Style* for other examples.

Journals:

1. van Dyke JR III, Von Trapp JT Jr, Smith BC Sr. Arthroscopic management of postoperative arthrofibrosis of the knee joint: indication, technique, and results. *J Bone Joint Surg Br.* 1995;19:517–525.
2. Council on Scientific Affairs. Scientific issues in drug testing. *JAMA.* 1987;257:3110–3114.

Books:

1. Fischer DH, Jones RT. *Growing Old in America.* New York, NY: Oxford University Press Inc; 1977:210–216.
2. Spencer JT, Brown QC. Immunology of influenza. In: Kilbourne ED, Gray JB, eds. *The Influenza Viruses and Influenza.* 3rd ed. Orlando, FL: Academic Press Inc; 1975:373–393.

Presentations:

1. Stone JA. Swiss ball rehabilitation exercises. Presented at: 47th Annual Meeting and Clinical Symposia of the National Athletic Trainers' Association; June 12, 1996; Orlando, FL.

Internet Sources:

1. Knight KL, Ingersoll CD. Structure of a scholarly manuscript: 66 tips for what goes where. Available at http://www.nata.org/jat/66tips. html. Accessed January 1, 1999.
2. National Athletic Trainers' Association. NATA blood borne pathogens guidelines for athletic trainers. Available at http://www.nata.org. Accessed January 1, 1999.

24. Table Style: 1) Tile is bold; body and column headings are roman type; 2) units are set above rules in parentheses; 3) numbers are aligned in columns by decimal; 4) footnotes are indicated by symbols (order of symbols: *, †, ‡, §, ||, ¶); 5) capitalize the first letter of each major word in titles; for each column or row entry, capitalize the first word only. See a current issue of the *Journal* for examples.
25. All black and white line art should be submitted in camera-ready form. Line art should be of good quality; should be clearly presented on white paper with black ink, sans serif typeface, and no box; and should be printed on a laser printer—no dot matrix. Figures that require reduction for publication must remain readable at their final size (either 1 column or 2 columns wide). Photographs should be glossy black and white prints. Do not use paper clips, write on photographs, or attach photographs to sheets of paper. On the reverse of each figure attach a write-on label with the figure number, name of the author, and an arrow indicating the top. (Note: Prepare the label before affixing it to the figure.) Authors should submit 1 original of each figure and 5 copies for review.
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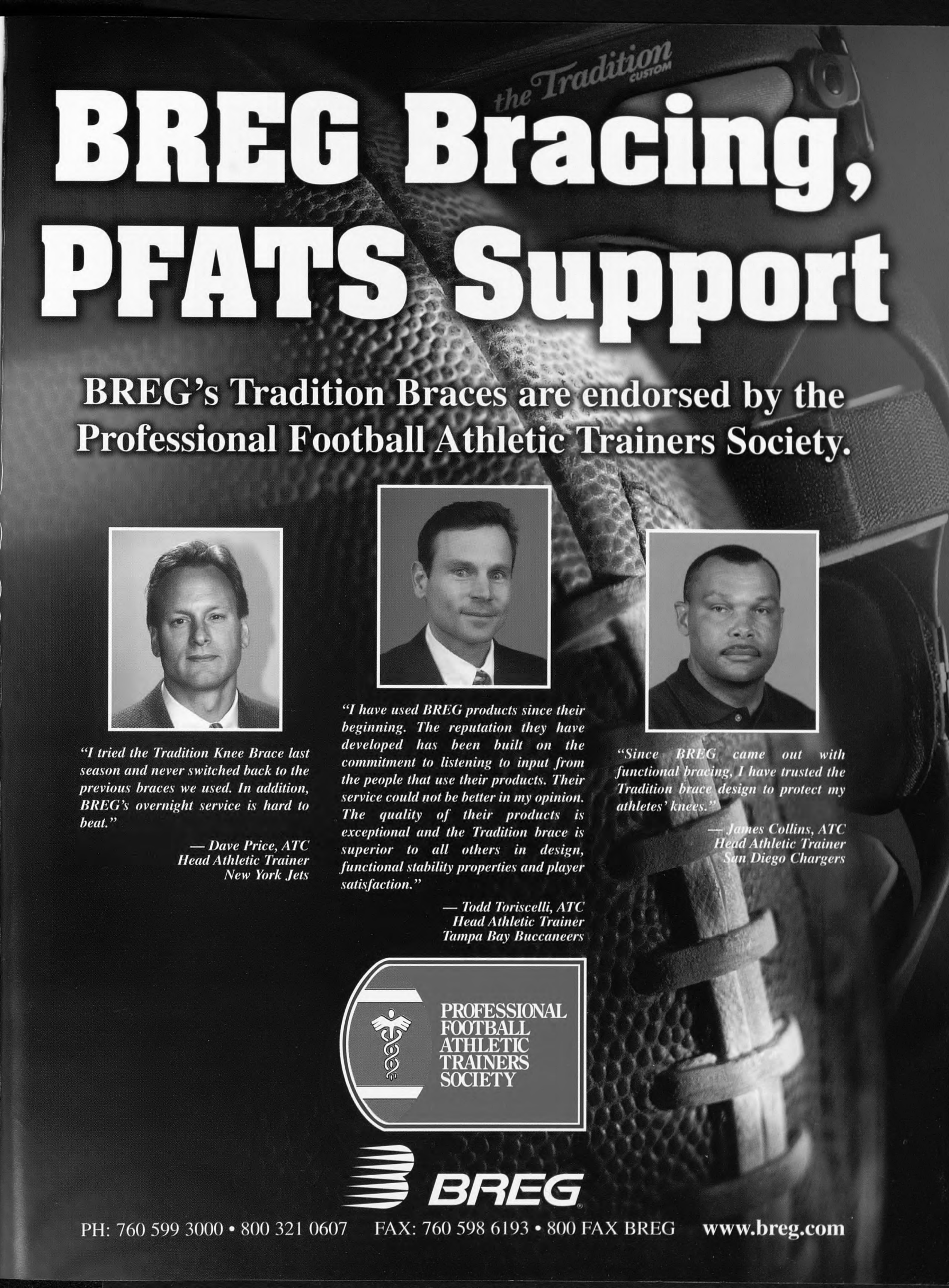
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