

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.				
1. REPORT DATE (DD-MM-YYYY) 14-06-2009		2. REPORT TYPE journal article		3. DATES COVERED (From - To) 2005-2008
4. TITLE AND SUBTITLE Gender differences in the incidence and prevalence of patellofemoral pain syndrome Volume 20, Pages 725-730 Scandinavian Journal of Medicine and Science in Sports			5a. CONTRACT NUMBER	
			5b. GRANT NUMBER NIH R01 AR050461-01	
			5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Boling, Michelle C (Author) Padua, Darin A (Author) Marshall, Stephen W (Author) Guskiewicz, Kevin (Author) Pyne, Scott (Author) Beutler, Anthony I (Author)			5d. PROJECT NUMBER	
			5e. TASK NUMBER	
			5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Michelle Boling, PhD, ATC University of North Florida 1 UNF Drive, Department of Athletic Training and Physical Therapy Jacksonville, FL 32246			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR'S ACRONYM(S)	
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited Administrative or Operational Use; 14 June 2009				
13. SUPPLEMENTARY NOTES Published in Scandinavian Journal of Medicine and Science in Sports, vol 20, pages 725-730, June 2009				
14. ABSTRACT The purpose of this investigation was to determine the association between gender and the prevalence and incidence of patellofemoral pain syndrome (PFPS). One thousand five hundred and twenty-five participants from the United States Naval Academy (USNA) were followed for up to 2.5 years for the development of PFPS. Physicians and certified athletic trainers documented the cases of PFPS. PFPS was defined as retropatellar pain during at least two of the following activities: ascending/descending stairs, hopping/jogging, prolonged sitting, kneeling, and squatting, negative findings on examination of knee ligament, menisci, bursa, and synovial plica, and pain on palpation of either the patellar facets or femoral condyles. Poisson and logistic regressions were performed to determine the association between gender and the incidence and prevalence of PFPS, respectively. The incidence rate for PFPS was 22/1000 person-years. Females were 2.23 times (95% CI: 1.19, 4.20) more likely to develop PFPS compared with males. While not statistically significant, the prevalence of PFPS at study enrollment tended to be higher in females (15%) than in males (12%) (P50.09). Females at the USNA are significantly more likely to develop PFPS than males. Additionally, at the time of admission to the academy, the prevalence of PFPS was not significantly different between genders.				
15. SUBJECT TERMS epidemiology, chronic knee injury, patellofemoral pain syndrome, anterior knee pain, injury rate, males, females				
16. SECURITY CLASSIFICATION OF: UU			17. LIMITATION OF ABSTRACT Public Release	18. NUMBER OF PAGES 6
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified		

Gender differences in the incidence and prevalence of patellofemoral pain syndrome

M. Boling¹, D. Padua², S. Marshall², K. Guskiewicz², S. Pyne³, A. Beutler⁴

¹Department of Athletic Training and Physical Therapy, University of North Florida, Jacksonville, Florida, USA, ²University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA, ³United States Naval Academy, Annapolis, Maryland, USA, ⁴Uniformed Services University of the Health Sciences, Bethesda, Maryland, USA

Corresponding author: Michelle C. Boling, PhD, ATC, Department of Athletic Training and Physical Therapy, University of North Florida, 1 UNF Drive, Jacksonville, Florida 32246, USA. Tel: +904 620 1563, Fax: +904 620 2848, E-mail: m.boling@unf.edu

Accepted for publication 14 June 2009

The purpose of this investigation was to determine the association between gender and the prevalence and incidence of patellofemoral pain syndrome (PFPS). One thousand five hundred and twenty-five participants from the United States Naval Academy (USNA) were followed for up to 2.5 years for the development of PFPS. Physicians and certified athletic trainers documented the cases of PFPS. PFPS was defined as retropatellar pain during at least two of the following activities: ascending/descending stairs, hopping/jogging, prolonged sitting, kneeling, and squatting, negative findings on examination of knee ligament, menisci, bursa, and synovial plica, and pain on palpation of either the patellar facets or femoral condyles. Poisson and logistic

regressions were performed to determine the association between gender and the incidence and prevalence of PFPS, respectively. The incidence rate for PFPS was 22/1000 person-years. Females were 2.23 times (95% CI: 1.19, 4.20) more likely to develop PFPS compared with males. While not statistically significant, the prevalence of PFPS at study enrollment tended to be higher in females (15%) than in males (12%) ($P = 0.09$). Females at the USNA are significantly more likely to develop PFPS than males. Additionally, at the time of admission to the academy, the prevalence of PFPS was not significantly different between genders.

Patellofemoral pain syndrome (PFPS) is one of the most common problems among physically active individuals between the ages of 15 and 30 (DeHaven & Lintner, 1986). Although very common, there is a lack of recent epidemiologic data regarding the prevalence and incidence of this condition. Additionally, it has commonly been assumed that PFPS occurs more frequently in females compared with males; however, there is scant recent epidemiologic data that supports this oft-quoted gender discrepancy.

Two forms of epidemiologic evidence that provide information on the occurrence of PFPS are prevalence and incidence. Prevalence describes the number of individuals within a population that have a specific condition at a specific time, while incidence describes the number of new onsets of a specific condition within a population over a period of time (Hennekens & Buring, 1987). Based on these definitions, prevalence takes into account both old and new occurrences of a condition at a point in time. Therefore, prevalence may be an overestimation of the incidence of PFPS because incidence only takes into

account new onsets of a condition. Epidemiologic incidence proportion (IP) is the most common measure of incidence that has been reported by researchers investigating PFPS (Milgrom et al., 1991; Witvrouw et al., 2000). The epidemiologic IP is described as the number of individuals with an injury divided by the number of individuals at risk (Knowles et al., 2006). Incidence rate has not been commonly reported by investigations assessing PFPS. This measure takes into account the amount of follow-up time for each individual before the development of PFPS. Prevalence and incidence both provide differing information about the occurrence of a condition and therefore can provide additional information that cannot be assumed through the presentation of one measure over another.

The prevalence of PFPS has been reported across several age groups, with females having a higher prevalence than males. Among patients ranging in age from 10 to 49 reporting to a sports medicine clinic, 70% of the PFPS cases were between the ages of 16 and 25 (Devereaux & Lachman, 1984). Additionally,

diagnosis of PFPS has been reported to account for 19.6% of all injuries in females and 7.4% of all injuries in males (DeHaven & Lintner, 1986). One investigation has reported the prevalence of PFPS to be approximately 1.5 times greater in females compared with males (Taunton et al., 2002). These investigations deal exclusively with prevalence data which tends to overestimate true disease burden because it accounts for both past and current cases. Therefore, to understand how PFPS is currently affecting individuals, it is important to determine the incidence of PFPS.

The epidemiologic IP of PFPS also has been investigated previously in physically active adolescents and young adults. Witvrouw et al. (2000) reported an 8.5% IP for PFPS in students participating in physical activity classes. Investigators have reported epidemiologic IPs for PFPS in military recruits due to the high physical demands of this population. These investigations have reported IPs ranging from 4% to 17% during basic training (Milgrom et al., 1991; Jordaan & Schwellnus, 1994; Wills et al., 2004). None of these investigations have reported if the IP of PFPS differs between males and females. Determining if a gender difference exists in the incidence of PFPS may provide evidence to support or refute the theory that females are more at risk for PFPS compared with males.

Finally, many studies reporting prevalence of PFPS were performed >20 years ago (Devereaux & Lachman, 1984; DeHaven & Lintner, 1986). With increasing female participation in sport, the gender-specific prevalence rate of this disorder may be drastically different than previously reported. Because of the lack of incidence data, a paucity of gender-based military studies, and an aging body of literature, our epidemiologic understanding of PFPS remains limited. The purpose of this study was to investigate the association between gender and the prevalence and incidence of PFPS in a military cadet population. We hypothesized that female military cadets would have a higher prevalence and incidence of PFPS compared with male military cadets.

Methods

Participants

One thousand five hundred and twenty-five participants from the United States Naval Academy (USNA) were enrolled in this investigation. Inclusion criteria for enrollment into the cohort population were (1) freshman at USNA at time of enrollment into the investigation and (2) no injury limiting participation in a jump-landing task and/or lower extremity strength tests. Enrolled participants were spread among three classes of midshipmen [class of 2009 = 438 participants (females = 189, males = 249), class of 2010 = 525 participants (females = 223, males = 302), and class of 2011 = 562 participants (females = 194, males = 368)]. Each participant filled out a baseline questionnaire during their first summer of enrollment at the USNA. This baseline assessment is part of

a larger scale investigation [Joint Undertaking to Monitor and Prevent-ACL injuries (JUMP-ACL)] in which data were collected during the summers of 2005, 2006, and 2007.

Participants in this investigation were followed prospectively for the diagnosis of PFPS from the time of their enrollment in this investigation to January 15, 2008. The diagnosis of PFPS was determined based on a review of medical records by the principal investigator. The criteria that needed to be met to be included in the PFPS group are listed below:

Must demonstrate both during evaluation

- (1) Retropatellar knee pain during at least two of the following activities: ascending/descending stairs, hopping/jogging, prolonged sitting with flexed knees, kneeling, and squatting.
- (2) Negative findings on examination of knee ligament, menisci, bursa, and synovial plica.

Must demonstrate one of the following during evaluation

- (1) Pain on palpation of medial or lateral patellar facets.
- (2) Pain on palpation of the anterior portion of the medial or lateral femoral condyles.

Although duration of symptoms is commonly accounted for when defining PFPS, we did not account for this because of the lack of consistent documentation of duration of symptoms by military health professionals. However, if the mechanism of injury stated a traumatic blow to the knee/patella and the medical record note matched the above-listed inclusion criteria, we did not include the individual in the injured cohort. Based on this, we attempted to only include individuals who developed PFPS over a period of time (chronic) and not due to an acute traumatic injury. Additionally, we continued to review medical records following the initial diagnosis of PFPS to determine if individuals underwent follow-up tests such as MRI. If an individual underwent follow-up tests, we reviewed the results of the tests to rule out a meniscal injury or synovial plica and confirm the initial diagnosis of PFPS.

Baseline demographic data collection

After providing informed consent in accordance with National Naval Medical Center Bethesda IRB guidance, study participants filled out the baseline questionnaire. The baseline questionnaire asked about age, gender, history of participation in athletic activity, mental health, knee and lower limb injury history, and recent exercise and weight training history. One of the questions in the baseline questionnaire asks specifically on the "occurrence of patellofemoral pain (severe knee pain or runner's knee) in the previous 6 months." These data were used to calculate the prevalence of PFPS in the cohort.

Follow-up of cohort

Physicians at USNA diagnosed cases of PFPS. Injury data were extracted for participants in this investigation from each participant's date of enrollment in this study to January 15, 2008. All injury information before April 2007 was collected through the Defense Medical Surveillance System (DMSS) and via medical chart review by the principal investigator. In April 2007, a general knee pain template used to diagnose

common chronic and acute knee injuries was added to the Armed Forces Health Longitudinal Technology Application (AHLTA) to be utilized by the physicians. AHLTA captures most illnesses and injuries in the United States Armed Forces resulting in a hospitalization or an ambulatory care facility visit to a military hospital or military clinician.

During the summer, not all medical records are entered into the AHLTA database due to clinics being held outside of the medical clinic. Therefore before April 2007, a “Standard Form 600” (SF600) was used by the physicians to document knee injuries. During the summer of 2007, a SF600 similar in content to the AHLTA knee pain template was developed and used by physicians and corpsmen to document knee injuries. All SF600s are filed within the medical record charts for midshipmen in Brigade Medical at the USNA. The International Statistical Classification of Diseases and Related Health Problems (ICD-9) for the diagnosis on the SF600s is entered into DMSS which also includes records within AHLTA.

A search through the DMSS was conducted to extract the following ICD-9 codes: 726.69 (unspecified knee enthesopathy), 726.64 (patellar tendonitis), 717.7 (patella chondromalacia), and 719.46 (unspecified disorder of joint in lower leg). We chose to include the above ICD-9 codes because there is not a specific ICD-9 code for PFPS. Also, based on our review of medical records and discussions with physicians at the USNA, these codes were the most commonly used when documenting PFPS. See Fig. 1 for PFPS data collection flowchart. Each participant's lower extremity injury history was evaluated following his/her respective enrollment date in this investigation. For example, if a participant entered the study July 10,

2006, his or her injury history was evaluated from July 10, 2006 through January 15, 2008.

The principal investigator searched through AHLTA using the social security number of the study participant to find the medical record that was associated with the ICD-9 code and date of the diagnosis extracted from DMSS. If the medical record associated with the ICD-9 code was not within the AHLTA database, the principal investigator had access to the hard copy of the medical record, which is stored at Brigade Medical at the USNA. Medical record notes were matched with the criteria for inclusion into the PFPS group. The principal investigator accessed AHLTA and medical record charts once every 2 months by traveling to the USNA or Uniformed Services University of the Health Sciences to determine the enrolled participants that had been diagnosed with PFPS.

Athletic injuries that were evaluated and treated by the certified athletic trainers at the USNA were not included in the medical records for midshipmen. The certified athletic trainers use SportsWare™ to record the athletic injuries they evaluate and treat. The principal investigator searched through SportsWare™ (CSMi Medical Solutions, Stoughton, Massachusetts, USA) to determine the varsity athletes who were diagnosed with PFPS. Because of variability in documentation by the certified athletic trainers in SportsWare™, another version of the SF600 was used by the certified athletic trainers following April 2007 to document specific evaluative findings for acute and chronic knee injuries. The principal investigator extracted information from SportsWare™ and the SF600s used by the certified athletic trainers every 2 months starting in April 2007.

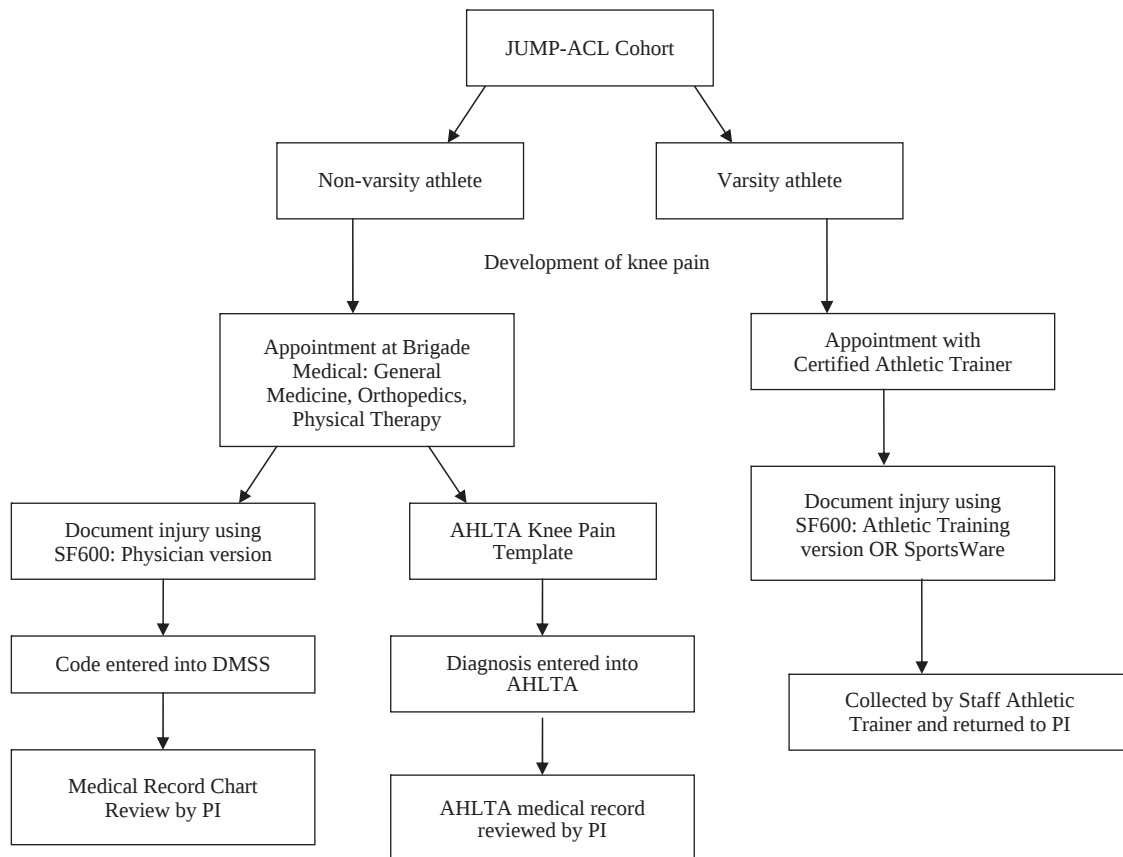


Fig. 1. Patellofemoral pain syndrome data collection.

Statistical analysis

The association between the incidence of PFPS and gender was investigated using Poisson regression. The incidence rate for PFPS was calculated by adding up the follow-up time for all participants, and dividing the number of individuals diagnosed with PFPS by the total follow-up time (years) multiplied by 1000 (person-years) [(# of injuries/total follow-up time) $\times$ 1000]. For the individuals who did not develop PFPS, follow-up time was 2.5, 1.5, or 0.5 years for the cohorts who enrolled in the summers of 2005, 2006, and 2007, respectively. Follow-up time was calculated separately for individuals who developed patellofemoral pain. For example, if an individual enrolled in July of 2005 and developed PFPS in July of 2006, their follow-up time would be 1 year.

The association between prevalence of PFPS and gender was investigated using logistic regression. All statistical analyses were performed using SAS 9.1 (SAS Institute Inc., Cary, North Carolina, USA). An a priori α level was set at 0.05.

Results

A total of 206 (females = 93, males = 113) individuals reported a history of PFPS and were removed from the analysis of incidence (but were used in the prevalence analysis). Based on the medical record review by the principal investigator, there were 45 participants (females = 27, males = 18) who were diagnosed with PFPS meeting criteria for inclusion in the PFPS group during the study period. Five of these individuals (females = 3, males = 2) had reported a previous history of PFPS and had been previously removed from the incident cohort. Thus, a total of 1319 participants (females = 513, males = 806) were included in the Poisson regression model for incidence. Forty of these participants were diagnosed with a new incidence of PFPS (females = 24, males = 16).

Prevalence

A total of 1525 participants (females = 606, males = 919) were included in the logistic regression model for prevalence. Two hundred and six participants (females = 93, males = 113) reported a history of PFPS. The logistic regression analysis revealed that gender was not a significant predictor of the prevalence of PFPS ($P = 0.09$). Although not significant, females were approximately 25% more likely to have a history of PFPS compared with males. The prevalence of PFPS was calculated by dividing the number of individuals who reported a history of PFPS ($n = 206$) by the total number of individuals in the cohort ($n = 1525$). The prevalence of PFPS in the cohort was 13.5% [95% confidence interval (CI): 11.7%, 15.3%]. The prevalence of PFPS in females and males was 15.3% (95% CI: 13.7%, 16.9%) and 12.3% (95% CI: 11.1%, 13.4%), respectively.

Incidence

The incidence rate for PFPS was 22/1000 person-years (95% CI: 15/1000, 29/1000 person-years). The incidence rate in females was 33/1000 person-years (95% CI: 20/1000, 45/1000 person-years) and the incidence rate in males was 15/1000 person-years (95% CI: 7/1000, 22/1000 person-years). Based on the Poisson regression analysis, gender was a significant predictor of the development of PFPS ($P = 0.01$), with females being 2.23 times more likely to develop PFPS compared with males (95% CI: 1.16, 4.10).

Discussion

The central finding of this investigation was the significant association between gender and the incidence rate of PFPS, with females being more likely to develop PFPS. Although there was no significant association between gender and the prevalence of PFPS, females tended to have an increased prevalence of PFPS compared with males. Based on previous research, we hypothesized that the incidence and prevalence of PFPS would both be significantly different between males and female. Although previous investigations have not statistically compared the prevalence of PFPS between males and females, the findings from previous investigations support females having a higher prevalence of PFPS compared with males.

Previous investigations have reported the prevalence of PFPS in females to be as high as two times that of males (DeHaven & Lintner, 1986; Taunton et al., 2002). These investigations have calculated the prevalence of PFPS based on visits to a sports medicine clinic by the general population. Our investigation used a self-report of injury from a baseline questionnaire for an investigation of risk factors for lower extremity injuries in a military population. Our findings do not agree with the previous investigations reporting a gender difference for the prevalence of PFPS. Differences in the populations assessed may have a large impact on the prevalence reported by our investigation and previous investigations. Also, one limitation of this investigation is that the prevalence of PFPS was calculated from those who reported suffering from PFPS during the 6 months before entering the USNA. If participants had a history of PFPS before the 6 months before entering the academy, but had not had any symptoms since then, they would have answered no to this question and are not included in the calculation of prevalence. Based on this, the estimation of prevalence of PFPS is most likely an underestimation of the true prevalence of PFPS, and this may partly explain why we did not find a gender difference in the prevalence of PFPS.

The prospective investigations in which the incidence of PFPS has been evaluated have either not statistically assessed the association between gender and the incidence of PFPS or the investigation only assessed the incidence of PFPS in males. We feel it is important to know that females have 2.23 times higher incidence of PFPS compared with males. Researchers speculate there are many biomechanical and anatomical alignment factors that may lead to the increased incidence of PFPS in females compared with males. These factors include differences between males and females on measures of *q*-angle, dynamic frontal plane alignment, and lower extremity muscle strength. In comparison to males, females have increased static measures of *q*-angle (Aglietti et al., 1983; Horton & Hall, 1989), increased dynamic measures of knee valgus angle, hip internal rotation angle, hip adduction moment, and knee valgus moment, and decreased dynamic measures of knee flexion angle (Malinzak et al., 2001; Lephart et al., 2002; Decker et al., 2003; Ford et al., 2003; Pollard et al., 2006; Sigward & Powers, 2006). On measures of strength, females have been reported to be significantly weaker than males on measures of quadriceps, hip external rotation, hip extension, and hip abductor strength (Leetun et al., 2004; Barber-Westin et al., 2006; Claiborne et al., 2006). All of these deficits in females are theorized to be risk factors for PFPS, and therefore, many researchers believe females have a higher prevalence and incidence of PFPS because they display these risk factors more commonly than males.

Multiple factors may have played into finding a difference in the incidence of PFPS between genders but not finding a difference in prevalence of PFPS between genders. The findings from this investigation of no differences in the prevalence of PFPS between males and females, does not agree with previous research. The service academies enroll significantly more males than females. Therefore, the service academies are likely not representative of the general population, especially the general female population (Cox & Lenz, 1979; Cox & Lenz, 1984). The lack of a gender difference in the prevalence of PFPS may be due to individuals being able to control their physical activity demands before entering the USNA, whereas after matriculation at USNA all individuals are required to participate in the same basic physical activity regimen. Additionally, individuals who are suffering from PFPS before enrollment in a college or university are most likely not going to enter a service academy due to the high activity demands that will be placed on them. Each of these factors might explain the similar prevalence in PFPS.

The gender difference found in the incidence of PFPS in this investigation may be influenced by the increased reporting of injuries in females compared

with males. Previous investigations have reported that with respect to male military recruits, female military recruits are significantly more likely to have a reported musculo-skeletal injury than an unreported musculo-skeletal injury (Almeida et al., 1999). It is not clear why this happens, however, many researchers believe the gender discrepancy in reporting of musculo-skeletal injuries may be due to the occupational stress felt by females when entering a field that has traditionally been male dominant (Almeida et al., 1999). Furthermore, gender socialization is another factor that may play into the increased reporting of musculo-skeletal injuries by females (Verbrugge, 1985). Previous research has reported that males are discouraged from reporting injuries and illnesses at an early age, but girls are taught that reporting injuries and illnesses is acceptable and should be done to take care of one's body (Verbrugge, 1985). Based on these investigations, psychosocial parameters are important factors to be considered when investigating gender differences in the incidence of musculo-skeletal injuries.

Although there are psychosocial factors that should be taken into account when investigating the prevalence and incidence of PFPS at the USNA, biomechanical differences between males and females may also explain the gender differences in the incidence of PFPS. We speculate that females and males most likely had very different physical activity levels before entering the USNA; however, once they entered the USNA, females and males are asked to perform at the same physical activity levels. The biomechanical differences that have been reported between males and females, such as decreased strength of lower extremity musculature and altered kinematics and kinetics during dynamic tasks, may explain the increased incidence of PFPS in females compared with males once these individuals were asked to perform at the same physical activity levels. Future investigations should assess the psychosocial aspects along with the proposed biomechanical risk factors, to determine what may lead to the increased incidence of PFPS in males compared with females. Also, future investigations should compare the prevalence of PFPS in the general population to a military population.

A limitation of this investigation is that this cohort population is not representative of the general population. Also, individuals suffering from PFPS before enrollment in a college or university are most likely not going to enter a service academy due to the high activity demands that will be placed on them, and therefore these individuals most likely self-selected themselves out of this cohort population. One final limitation of this investigation is that the criteria for inclusion in the injured group lack specificity. Because of the lack of specificity, individuals who were

tender to palpation over the patellar tendon and either the patellar facets or femoral condyles could have been included in the injured group. In our investigation, this only occurred in two individuals in the injured group (5% of injured cohort) and therefore we do not feel this had a major affect on the results of this investigation. Additionally, it is important to note that based on the medical record reviews and discussions with physicians at the USNA, the criteria listed was the most specific that we could be to capture PFPS in this population.

Perspectives

Females at the USNA have 2.23 times the incidence of PFPS compared with males. There was also a non-significant association between gender and the prevalence of PFPS (15% in females vs 12% in males). It is important for future investigations to determine

the factors that lead to this gender difference. Prospective risk factor investigations need to be conducted in both the military and general population to provide a clearer understanding of the factors that lead to a higher incidence of PFPS in females compared with males.

Key words: epidemiology, chronic knee injury, anterior knee pain, injury rate, males, females.

Acknowledgements

This project was supported by grant R01 AR050461 from the National Institute of Arthritis and Musculo-skeletal and Skin Diseases. Funds for the pilot study were provided by the American Orthopaedic Society for Sports Medicine (AOSSM). Additional funding was provided by the National Academy of Sports Medicine (NASM).

References

- Aglietti P, Insall JN, Cerulli G. Patellar pain and incongruence. I: measurements of incongruence. *Clin Orthop Rel R* 1983; 176: 217–224.
- Almeida SA, Trone DW, Leone DM, Shaffer RA, Patheal SL, Long K. Gender differences in musculoskeletal injury rates: a function of symptom reporting? *Med Sci Sport Exer* 1999; 31: 1807–1812.
- Barber-Westin SD, Noyes FR, Galloway M. Jump-land characteristics and muscle strength development in young athletes: a gender comparison of 1140 athletes 9 to 17 years of age. *Am J Sport Med* 2006; 34: 375–384.
- Claiborne TL, Armstrong CW, Gandhi V, Pincivero DM. Relationship between hip and knee strength and knee valgus during a single leg squat. *J Appl Biomech* 2006; 22: 41–50.
- Cox JS, Lenz HW. Women in sports: the naval academy experience. *Am J Sport Med* 1979; 7: 355–357.
- Cox JS, Lenz HW. Women midshipmen in sports. *Am J Sport Med* 1984; 12: 241–243.
- Decker MJ, Torry MR, Wyland DJ, Sterett WI, Steadman J. Gender differences in lower extremity kinematics, kinetics and energy absorption during landing. *Clin Biomech* 2003; 18: 662–669.
- DeHaven KE, Lintner DM. Athletic injuries: comparison by age, sport, and gender. *Am J Sport Med* 1986; 14: 218–224.
- Devereaux M, Lachman S. Patellofemoral arthralgia in athletes attending a sports injury clinic. *Br J Sport Med* 1984; 18: 18–21.
- Ford KR, Myer GD, Hewett TE. Valgus knee motion during landing in high school female and male basketball players. *Med Sci Sport Exer* 2003; 35: 1745–1750.
- Hennekens C, Buring J. *Epidemiology in medicine*, 1st edn. Boston: Little, Brown, 1987.
- Horton MG, Hall TL. Quadriceps femoris muscle angle: normal values and relationships with gender and selected skeletal measures. *Phys Ther* 1989; 69: 897–901.
- Jordaan G, Schwellnus MP. The incidence of overuse injuries in military recruits during basic military training. *Mil Med* 1994; 159: 421–426.
- Knowles SB, Marshall SW, Guskiewicz KM. Issues in estimating risks and rates in sports injury research. *J Athl Training* 2006; 41: 207–215.
- Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. *Med Sci Sport Exer* 2004; 36: 926–934.
- Lephart SM, Ferris CM, Riemann BL, Myers JB, Fu FH. Gender differences in strength and lower extremity kinematics during landing. *Clin Orthop Rel R* 2002; 401: 162–169.
- Malinzak RA, Colby SM, Kirkendall DT, Yu B, Garrett WE. A comparison of knee joint motion patterns between men and women in selected athletic tasks. *Clin Biomech* 2001; 16: 438–445.
- Milgrom C, Kerem E, Finestone A, Eldad A, Shlamkovitch N. Patellofemoral pain caused by overactivity. A prospective study of risk factors in infantry recruits. *J Bone Joint Surg* 1991; 73A: 1041–1043.
- Pollard CD, Sigward SM, Ota S, Langford K, Powers CM. The influence of in-season injury prevention training on lower-extremity kinematics during landing in female soccer players. *Clin J Sport Med* 2006; 16: 223–227.
- Sigward SM, Powers CM. The influence of gender on knee kinematics, kinetics and muscle activation patterns during side-step cutting. *Clin Biomech* 2006; 21: 41–48.
- Taunton J, Ryan MB, Clement D, McKenzie D, Lloyd-Smith D, Zumbo B. A retrospective case-control analysis of 2002 running injuries. *Br J Sport Med* 2002; 36: 95–101.
- Verbrugge LM. Gender and health: an update on hypotheses and evidence. *J Health Soc Behav* 1985; 26: 156–182.
- Wills AK, Ramasamy A, Ewins DJ, Etherington J. The incidence and occupational outcome of overuse anterior knee pain during army recruit training. *J R Army Med Corps* 2004; 150: 264–269.
- Witvrouw E, Lysens R, Bellemans J, Cambier D, Vanderstraeten G. Intrinsic risk factors for the development of anterior knee pain in an athletic population: a two-year prospective study. *Am J Sport Med* 2000; 28: 480–489.