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Sex Differences in “Weightlifting” Injuries Presenting to United States Emergency Rooms

Carmen E. Quatman^{1,2}, Gregory D. Myer^{1,3}, Jane Khoury^{1,4}, Eric J. Wall^{1,5}, and Timothy E. Hewett^{1,6}

¹Cincinnati Children’s Hospital Medical Center, Sports Medicine Biodynamics Center and Human Performance Laboratory

²University of Toledo, Engineering Center for Orthopaedic Research Excellence

³Graduate Program in Athletic Training, Rocky Mountain University of Health Professions

⁴Center for Epidemiology and Biostatistics

⁵Division of Pediatric Orthopaedic Surgery

⁶Departments of Pediatrics, Orthopaedic Surgery, College of Medicine and the Departments of Biomedical Engineering and Rehabilitation Sciences, University of Cincinnati

Abstract

Benefits of resistance training include improved muscle strength and sports performance, and may include reduced injuries. However, few studies have examined sex differences in resistance training related injuries. The objective of this investigation was to evaluate sex differences in injuries associated with weightlifting, in adolescents and young adults by type (sprains and strains, fractures), mechanism (accidental, non-accidental) and location (head, trunk, arm, hand, leg, foot) of injury. We hypothesized that there would be sex differences in type, mechanism and location of “weightlifting” injuries. The US Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) was queried from 2002-2005, using the CPSC code for “Weightlifting.” Subjects between the ages of 14 and 30 were included in the study. CPSC sampling weights were used to calculate national estimates from the sample of 3,713 patients (Males= 3,102; Females= 611). Weighted Chi-square analyses were used to compare differences in mechanism, type, and location of injury for males versus females. Males had significantly more sprains and strains ($P=0.004$), while females demonstrated increased accidental injuries compared to males ($P<0.001$). The trunk was the most commonly injured body part for both males (36.9%) and females (27.4%). However, males had more trunk injuries than females ($P<0.001$), while females had more foot ($P<0.001$) and leg ($P=0.03$) injuries than males ($P<0.001$). The findings indicate that males may suffer more exertional type resistance injuries during weightlifting (sprains and strains) compared to females, especially at the trunk. Conversely, females may be more susceptible to lower extremity injuries resulting from accidents during resistance training.

INTRODUCTION

Since the passage of Title IX of the Educational Assistance Act in 1972, female participation in high school sports has increased more than 9-fold with over 3 million females participating in sports during the 2006-2007 school year.(40) The increase in female sports participation has

lead to a resultant increase in injuries in this population. In particular, the number of knee injuries has increased dramatically,(1-3,6) and adolescent females more commonly experience overuse injuries, such as patellofemoral pain.(5) Female athletes participating in sports also have a greater propensity for the development of the female athlete triad (low energy level availability, menstrual disorders, and bone loss) which may progress into significant long term problems such as eating disorders, amenorrhea, and osteoporosis.(38)

Recent evidence indicates that training programs that incorporate resistance training can reduce injuries while improving sports related performance in female athletes (16,21,25,26,33-35). Consequently, resistance training is gaining popularity in the female sports populations.(40) Resistance training may also potentially reduce the propensity for the development of the female athlete triad and increase self-esteem and body image satisfaction in female athletes. (4,44) While the use of resistance training in female populations has increased dramatically in the past two decades, an extensive literature search revealed few studies reporting risks involved with resistance training participation in females.

The objective of this investigation was to evaluate sex differences for weightlifting injuries in adolescents and young adults presenting to United States emergency rooms by type (sprains and strains, fractures), mechanism (accidental, non-accidental) and location (head, trunk, arm, hand, leg, foot) of injury. We hypothesized that there would be sex differences in accident-related injuries that would be potentially reflective of supervision and experience. We hypothesized that there would be increased trunk injuries during weightlifting in males relative to females indicative of relative resistance training intensity.

METHODS

The US Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) was queried from 2002-2005, using the CPSC code for “Weightlifting” (Product ID # 3265). The NEISS database is a national probability sample of the hospitals in the US and US territories with sampling sites spread throughout the country. Sampling weights provided by CPSC were used to account for study design in the analysis and calculate national injury estimates. Subjects between the ages of 14 and 30 were included in the study. Injuries sustained under the influence of alcohol or other recreational drugs as reported by the hospital staff, injuries that were categorized as weightlifting but were not associated with weightlifting in the gym (e.g. hurt while shopping at a sporting goods store), subjects that did not have a clearly defined mechanism of injury, or subjects that left without seeing a physician, were eliminated from the sample (378 subjects eliminated from a total sample of 4,091). All data were quality controlled by cross referencing the specific comments to the CPSC category code. Type of injury (sprains/strain or fracture) and body location of injury (head, arm, trunk, leg, foot) were reported for each subject. In addition, each injury was classified into a mechanism of injury termed “non-accident” or “accident” based on the specific comments CPSC category. The mechanism of injury was considered non-accidental if it resulted from exertion (sprain/strain, fatigue failure, headache), equipment malfunction (cable snapping, resistance bands breaking), or from overuse (tendonitis). The mechanism of injury was considered accidental if it resulted from dropped weights, improper use of equipment, or tripping over equipment. The mechanism of injury was categorized by two separate reviewers blinded to both age and sex of the subjects. One reviewer performed the initial categorization while the second reviewer performed a separate, independent categorization while performing a quality control audit of the data. If the reviewers were unable to reach an agreement about the mechanism of injury or if the reviewers were unable to determine the injury mechanism from the description, the data were excluded from the sample. The differences between sexes were determined for type, mechanism, and location of injury. In addition, the “accidental”

injuries were screened out and additional analyses were run to determine type and body part injured for “true” weightlifting injuries.

Statistics

Statistical analyses were performed using SAS®, version 9.1 (SAS Institute, Cary, NC). In order to account for the survey design and to use the appropriate standard errors, the survey specific procedures, which incorporated the sample weights and design clusters, were used for analysis. The independent variable of interest, sex, had two categories, male and female. Weighted Chi-square analysis was used for the initial comparison of the proportion of type of injury, accidental versus non-accidental, and sprain/strain versus non-sprain/strain, for males and females. Weighted logistic regression was used to further elucidate the gender differences and to estimate the odds ratio (OR) and associated 95% confidence interval (CI). The level of statistical significance was established a priori at $p \leq 0.05$.

RESULTS

3,713 (3,102 males and 611 females) patients treated at participant NEISS emergency rooms between January 1, 2002 and December 31, 2005 met the inclusionary criteria for the analysis of weightlifting injuries. Hence, females comprised 16.5% of the population. Based on the NEISS database sampling weights, an estimated 114,441 males and 22,592 females between the ages of 14 and 30 were treated in US emergency rooms for weightlifting injuries from 2002-2005. Therefore, an approximate 6 to 1 disparity in weightlifting injuries prevalence was observed between males and females from this sample. This disparity remains when the accidental injuries are removed, resulting in cohorts of 77,145 males and 12,458 females.

Comparisons between the sexes for accident related injuries showed that females had significantly higher odds of accidental weightlifting injuries compared to males ($P < 0.001$, $OR = 1.69$; 95% $CI = 1.37$ to 2.08 ; Table 1). Specific anthropometric categorization of accidental injuries revealed that females had a higher odds of accidental foot injuries compared to males ($P < 0.001$, $OR = 2.44$; 95% $CI = 1.75$, 3.45) while males demonstrated increased odds of accidental hand injuries compared to females ($P < 0.001$, $OR = 2.14$; 95% $CI = 1.49$, 3.07).

When overall injuries were evaluated, males had significantly greater odds of sprains and strains ($P = 0.004$, $OR = 1.34$; 95% $CI = 1.10$ to 1.65) compared to females (Table 1). There was no difference in reported fracture injuries from weightlifting between the sexes ($P = 0.37$). The trunk was the most commonly injured body part for both males (36.9%) and females (27.4%, Figure 1). However, males had significantly greater odds of trunk injuries compared to females ($P < 0.001$, $OR = 1.55$; 95% $CI = 1.25$ to 1.96). Females reported greater odds of foot ($P < 0.001$, $OR = 2.63$; 95% $CI = 2.04$ to 3.45) and leg ($P = 0.03$, $OR = 1.54$; 95% $CI = 1.05$ to 2.22) injuries compared to males.

DISCUSSION

In the current study, females comprised only 16.5% of the overall weightlifting injuries in the study population, an approximate 6 to 1 disparity. This disparity is likely a reflection of the lower number of females participating in resistance training activities, rather than to females suffering injuries “less often” than males during resistance training. Resistance training is considered a popular and effective form of conditioning for sports performance enhancement and is commonly incorporated into most male sports training programs.(13) Unfortunately, the only weightlifting participation sex ratio data available is at the high school level from the National Federation of State High Schools (NFHS) Athletics Participation Survey and no epidemiology studies have been published regarding weightlifting participation at any level.

Prior to Title IX, female participation in high school weightlifting was uncommon (NFHS database, Figure 2). However, as female participation in sports has increased over the past three decades, the prevalence of females participating in high school weightlifting has likely increased as well. Despite this relative increase, the sex difference in weightlifting participation remains much greater than the sex difference in overall sports participation (Figures 2 and 3). Participation estimates from the High School Athletics Participation Survey conducted by the NFHS during the 2004-2005 school year, show that the ratio of males to females for overall sports participation was 1.4:1, while the ratio for weightlifting was 3:1.(39) While no current epidemiology studies are available to determine whether there is a sex difference in resistance training participation, the NFHS survey indicates that a 3:1 male to female sex discrepancy most likely exists.(41) Unfortunately, there is little data published in the literature to warrant an objective weightlifting incidence rate sex comparison at this time.

The higher risk of accidental injuries in female athletes found in this analysis is of particular concern. Common accidental injuries included dropped weights, improper use of equipment, or tripping over equipment; many of which may have been prevented with proper education and supervision. Resistance training is an integral component of most high school and collegiate football, wrestling, baseball, and basketball training programs. These factors reflect that most male sports training programs allocate significant staffing and supervision to improve the efficacy and safety of their training programs. In comparison, females may not have similar access, desire, or available resources to incorporate resistance training into their sports programs. Females, and their coaches, may also have concerns relating to increased injury or other perceived potential negative side effects of weightlifting participation. Since females have lower participation numbers in resistance training than males,(41) these findings may indicate that females may not have adequate supervision or proper education in resistance training techniques.

If an athlete performs resistance training exercises inappropriately at low resistance levels, then the risk of injury will be amplified at higher resistance levels. Females may benefit from resistance training programs that provide strict safety guidelines, education and appropriate supervision with emphasis on proper lifting techniques.

The higher risk for lower extremity injury in females compared to males is consistent with reports in other sports activities.(1,6,43) While the percentages of leg injuries were relatively low in both sexes, the higher risk in females could indicate underlying neuromuscular deficits. Several studies have shown that neuromuscular training that incorporates resistance training can reduce knee injuries in adolescent and mature female athletes.(21,31,37) Thus, a properly supervised resistance training program could be of particular importance for females in reducing not only resistance training injuries but in reducing injuries during sports competition as well.(36)

The higher risk of sprains and strains in the male population compared to females in this study is an interesting finding. Sprains and strains often result from exertion during activity. Males may train at higher relative intensity levels during resistance training; lifting heavier weights and attempting more difficult lifting techniques than females. This may put them at higher risk for developing exertion type injuries such as sprains and strains. Moreover, males had significantly more trunk-related injuries than females, which may be reflective of inappropriate selection of resistance intensity by male athletes. Coutts and Colleagues(12) demonstrated that supervised resistance training improved strength gains and exercise adherence in young athletes versus unsupervised training. Mazzetti et al.(32) corroborated these findings when they found similar results in male athletes who had moderate experience with resistance training. Cumulatively, there is strong evidence to support the benefits of direct supervision to improve both the efficacy and safety of resistance training applied to young athletes. In addition,

appropriate progressions of intensity of the resistance exercises, while maintaining the quality of exercises, may be critical in achieving successful outcomes from resistance training.(23)

A well designed resistance training program can increase strength in female athletes.(7,9,10, 15) Resistance training may provide significant performance and injury prevention benefits to female athletes, as they often display decreased baseline levels of strength and power compared to males.(19,22,28) Myer et al. demonstrated that females may improve strength measures as much as 92% with just 6 weeks of training.(35) Moreover, while both males and females show similar growth and development patterns associated with puberty, the sexes demonstrate significant differences in neuromuscular patterns after the onset of puberty (8,29). During puberty, males often demonstrate increases in power, strength and coordination, while no similar increases have been demonstrated in females(8,29) Musculoskeletal growth during puberty, in the absence of a corresponding neuromuscular spurt, may lead to neuromuscular imbalances (20) and place female athletes at risk for injury (17,18). Participation in resistance training programs may help female athletes achieve a neuromuscular spurt (27,30) similar to the spurt experienced by males.

Another major clinical problem unique to female athletes is the female athlete triad. The female athlete triad encompasses 3 medical conditions (low energy availability, menstrual disorders, and low bone mineral density) that often overlap in athletic females. These conditions may lead to significant long term health problems such as infertility, osteoporosis, and eating disorders.(38) In the past, many females have been afraid to participate in resistance training due to a fear of “bulking up.” Intensive neuromuscular training significantly increases fat free mass in adolescent females.(42) However, studies have shown that females that participate in resistance training programs feel healthier, more fit and have an improved body image.(4,44) Ahmed and colleagues studied females who participated in a 12 week resistance training program and then they questioned participants about body image, health and fitness. Results of this study showed that the females that participated in the resistance training program felt more confident, toned, healthier and more positive about their body.(4) Thus, resistance training may help counteract female athlete triad conditions by improving self-esteem and body image satisfaction and by increasing fat-free mass, bone mineral density, and the strength of tendons and ligaments.(14,24)

Limitations

The limitations of the current study are mainly associated with the NEISS dataset. The categorizations for injury caused by a weightlifting activity and for mechanisms of injury (accident or non-accident) are limited by the coding and comments provided by treating emergency room clinicians. While the NEISS database has a specific code related to “weightlifting” it is possible that the injuries reported were not necessarily a result of resistance training activities. The database reflects injuries that occur while using a specific product (weights or resistance training equipment) and it is dependent on individual treating clinicians to determine whether the injury falls under the code for weightlifting. However, in addition to coding, emergency room clinicians provided specific comments linked to each injury mechanism in the NEISS database. This allowed the investigators to assess the injury mechanism and “weightlifting” activity to confirm the data quality control. While the data categorization for mechanism of injury was not totally objective in nature since it was limited by the interpretation of the investigators, the reviewers were blinded to age, sex and overall injury estimates to increase the level of objectivity.

Due to the broad categorizations used for database coding, the information derived from studies using the NEISS database must be carefully evaluated and interpreted. It is important that study questions, hypotheses, and methods are established before utilizing the database since the same database may reveal different results depending on the dates used for review and the inclusion/

exclusionary criteria used to study a specific question and test hypotheses. For the current analysis, the years 2002-2005 were used to sample the NEISS database since 2002-2005 were the most recent years digitally available from the CPSC at the time of sampling. In addition, the age range (14-30 years) chosen for inclusionary criteria in this study was selected to reflect the age groups most likely to engage in resistance training activities on a consistent basis (high school, college, and young adult). Thus, the results for the current analysis should only be used to describe the sex differences in weightlifting injuries for the age ranges of 14-30.

At the same time, it is unknown whether multiple visits were made by the same person to the emergency room for a specific weightlifting injury. If the same person reported to the emergency room multiple times this would lead to an overestimation of the overall injury prevalence. However, the NEISS coding manual instructs hospital workers to record only the first emergency room visit for any specific injury,⁽¹¹⁾ thus it is unlikely that multiple visits by the same person for a specific injury were recorded. In addition, the NEISS coding manual instructs hospital workers to record only the most severely affected body part associated with an injury incident. Thus, the frequency of additional minor injuries accompanying an injury incident may be underrepresented. The dataset is not all-encompassing in terms of “weightlifting” injuries, since we cannot account for injuries that may not have resulted in an emergency room visit because treatment was available at the setting of injury (e.g. athletic trainers or team physicians), treatment was sought at other medical facilities, or treatment was not sought out for an injury.

Injury rates by sex and age could not be calculated because, the denominator, accurate numbers of adolescents and young adults participating in resistance training activities, and the associated exposure time are not available. Finally, this data cannot be generalized to athletes, skill level, or physical fitness since the NEISS database does not distinguish between recreational, high school, collegiate, athletes or whether the weightlifting injury occurred during “structured” (developed programs monitored by coaches, teachers, or trainers) or “unstructured” (no formal program or supervision) activities.

Despite these limitations, the results presented in this study provide important information about weightlifting injury patterns of high school and college aged populations. To our knowledge, no data are available that compare male and female resistance training injuries and this study is the only nationally representative stratified probability sample of weightlifting injuries categorized by age, sex, and mechanism of injury that resulted in US emergency room visits. A controlled case study or cohort study may provide “more accurate” results, however, the logistics of such a study that would capture enough resistance training injuries to reach adequate power for analyses would be challenging. While the limitations to this study are known, this information provides the groundwork necessary to establish differences in male and female resistance training injuries. Future work should focus on the determination of whether technique training, proper supervision, stricter safety guidelines or other modifications can make resistance training safer for both sexes at all ages and levels of participation.

PRACTICAL APPLICATIONS

During weightlifting activities, females demonstrated a higher risk of accidental injuries and suffered more lower extremity injuries compared to males. Males, on the other hand, suffered more exertional type resistance training injuries such as sprains and strains compared to females, particularly at the trunk. To reduce the occurrence of accidental injuries in females, an emphasis should be placed on safe equipment use, proper lifting techniques, stricter safety guidelines and appropriate supervision. To reduce the occurrence of exertional injuries, increased supervision to improve techniques at high intensity and improve appropriate resistance intensity selection may be beneficial for both sexes.

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Figure 1. Percentage of injuries at each body location for females and males. Note that the small prevalence of head injuries in the female category provides invalidated results and should be interpreted with caution.

Figure 2.

Reported high school weightlifting participants after the induction of Title IX (School years 1973-2005) based on the participation estimates from the High School Athletics Participation Survey conducted by the National Federation of State High School Associations.

Figure 3.

Reported high school sports participants after the induction of Title IX (School years 1973-2005) based on the participation estimates from the High School Athletics Participation Survey conducted by the National Federation of State High Schools Associations.

Table 1

Accidental and sprain/strain weightlifting injuries.

	Accidental Injuries	Weighted %	OR (95% CI)	Sprain/Strain	Weighted %	OR (95% CI)
Male	977	32.60%	0.59 (0.48, 0.73)	1797	56.60%	1.34 (1.10, 1.65)
Female	278	44.80%	reference	305	49.20%	reference
P-Value			P<0.001			P<0.001