Physical Activity and Musculoskeletal Injuries in Women: The Women's Injury Study

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Abstract

Background: Increased injury rates have been associated with physical activity (PA). The differences in musculoskeletal injury (MSI) characteristics resulting from PA, versus those unrelated to PA, are unknown. We describe the pattern of PA and non-PA MSI incurred by community-dwelling women.

Methods: Data were extracted from the Women's Injury Study, a web-based observational study that tracked weekly PA behaviors and self-reported MSI of 909 community-dwelling women ages 20–83 years. The primary outcome was self-reported MSI that interrupted daily activities ≥ 2 days and/or required treatment from a health care provider. Follow-up telephone reporting of MSIs allowed further description of injuries. Mixed effects logistic regression was used to identify injury sites associated with PA, controlling for age, body mass index, previous injury, and use of alcohol.

Results: Incidence of PA and non-PA MSIs were comparable; some differences in injury characteristics were evident across 83,241 person-weeks of reporting. Non-PA MSIs were more likely to come on “suddenly” (54% vs. 8%) and commonly involved head/jaw/neck injuries. Reported PA-related MSIs were less likely to require health care provider treatment (60% vs. 80%) and resulted in less missed days of work/school (11%) versus non-PA MSIs (17%). Compared to non-PA related injuries, PA-related injuries were more likely to involve the lower (odds ratio [OR]=3.10, $p=0.002$) or upper limbs (OR=2.54, $p=0.01$) and less likely to involve the head/jaw/neck (OR=0.21, $p=0.002$).

Conclusion: There are some differences in mechanisms of injury, the distribution of injuries by anatomical location, and the treatment of injuries depending on aerobic activity participation, although absolute rates of MSI were comparable.

Introduction

THE UNITED STATES DEPARTMENT of Health and Human Services physical activity guidelines (PAG) summarize the research relating physical activity (PA) to health outcomes.¹ Recommendations are made for moderate-to-vigorous PA (≥ 150 minutes per week) and muscle-strengthening activities (≥ 2 days per week). Increased amounts of PA are associated with increased risk of injury.^{2–4} However, the specific nature of the musculoskeletal injury (MSI) is infrequently reported. While injury rates are associated with increased PA, it is not known if the characteristics of MSIs resulting from PA are substantially different from those occurring within the same time frame, yet are unrelated to PA. If there are differences, this has implications for health care professionals, for trainers, and for individuals adopting or maintaining physically active lifestyles. However, if there are

similarities between the types of MSIs incurred, this provides additional validation of the important role that PA behaviors can have on quality of life without substantially increasing the MSI risk beyond that in general living activities.

Our purpose is to report the nature and types of MSIs reported in real-time in community-dwelling women. We describe the MSIs resulting as a consequence of PA and contrast those with MSIs incurring unrelated to PA. The intent is to contrast the types (PA vs. non-PA) and nature of MSIs for women injured while engaging in PA with MSIs occurring unrelated to PA behaviors.

Materials and Methods

Study population

Data were extracted from the Women's Injury Study (WIN), a web-based observational 3-year study that tracked

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the physical activity behaviors and self-reported MSIs of free-living adult women ages 20–83 years. Participants were recruited in waves from a database of more than 6000 women who visited, contacted, or completed health and fitness assessments at The Cooper Institute in Dallas, Texas. Additional recruitment included advertisements, health fairs, and community meetings. Active recruitment continued until we reached our minimum goal of 885 participants.

Inclusion criteria required access to a computer and internet, with basic skills to self-report relevant data. Exclusion criteria included (1) persons using assistive devices or with an acute or chronic disease/condition limiting mobility or interfering with leisure, occupational, or recreational activities at the time of baseline assessment, and (2) those planning to leave the area within 2 years.⁵ The Cooper Institute, University of North Texas, and Texas Woman's University institutional review boards reviewed and approved the study annually.

Study process

Eligible participants attended an orientation session to become familiar with study protocol and complete informed consent. The overall structure of the study included (1) a 2-week practice phase during which women entered weekly PA and MSI data, followed by completion of the baseline examinations and (2) an ongoing surveillance program that lasted up to 3 years. Components of the baseline assessment included self-report of demographic data, medical and orthopedic history, history of injury, and an orthopedic examination by physical therapists. Measured weight and height were obtained to calculate body mass index (BMI).

Web site surveillance

WIN participants primarily reported on a secure website weekly physical activity behavior in days per week and minutes per day and incidence of MSI. Participants received pedometers (Accusplit Eagle 120 XL) to record total weekly steps and days of pedometer wearing. Participants reported information on aerobic activity and strength training activities completed during the previous week. The PA questions were based on the CDC's Behavioral Risk Factor Surveillance System questions. Paper activity logs were distributed in case events arose preventing participants from completing the online activity logs. Prior research has shown that a combination of traditional and internet based surveys increase response rates, possibly due to participants feeling less pressured.^{6,7}

A MSI was defined as an injury (new, old, or recurrent) this week that caused you to see a health care provider or interrupt your daily activities for 2 or more days. All self-reported MSIs were confirmed by telephone within 48–72 hours. During this phone call a complete description of the PA MSI including body part, self-treatment, activity, and other relevant information provided the opportunity to fully describe how the MSI was obtained. However, due to the study design, documentation of specific activity in which non-PA MSIs occurred was not collected. The specific kind of injury (sprain, strain, contusion, etc.) was not obtained for any MSIs. All surveillance calls were completed by trained personnel who followed standard operating procedures. Questions regarding anatomical location of injury, injury severity, need to see

health care provider, and mechanism associated with the injury event were asked. Distribution of injuries ranged from head to toe and were categorized into head/jaw/neck, upper body, and lower body (from hips down). A five-mechanism response set described the manner in which each participant sustained the current injury, including "colliding, tripping, or falling; contact by an object, animal, or person; motor vehicle accident or other vehicular trauma; came on gradually and got worse with activity; and came on suddenly with no apparent cause." The average number of PA weeks reported during the study by MSI category was recorded to ensure each subgroup adequately contributed to the total timeframe of data collection. A full description of the reported PA behaviors is presented in Bain et al.⁵ We describe MSI as PA-related or independent of PA with the intent of ascertaining whether the types and sequela of MSI are similar.

Statistical analyses

We used a generalized linear mixed effects model to identify injury sites with different tendencies to injuries related to PA or not. This model had the form of a multiple logistic regression with random effects to accommodate correlation between multiple injuries within subjects. In addition to sites of injury, this model included covariates of age, BMI, previous injury, and use of alcohol to control for these factors. Cubic splines were used to accommodate nonlinear relationships between the outcome and the continuous factors age and BMI. We used SAS/STAT® software, version 9.2 (SAS Institute Inc.) for all analyses.

Results

Nine-hundred and nine (909) women are presented across an average of 1.89 person-years. As reported,² 80% of participants remained active through the conclusion of the study, and more than 95% of active participants completed at least 75% of their weekly reports. As seen in Table 1, categories represent participants who obtained at least one PA-related MSI or who obtained exclusive non-PA-related MSIs on one or more occasions during the length of the study. Participants were primarily middle aged (40–69 years), educated (≥ 12 years), Caucasian (77%) women. Measured BMI was somewhat similar among categories: normal weight ($< 25 \text{ kg/m}^2$), 39%; overweight ($25\text{--}29.9 \text{ kg/m}^2$), 32%; and obese ($\geq 30 \text{ kg/m}^2$), 28%. Across the study, 45% of women did not report PA levels sufficient for meeting National Physical Activity Guidelines (PAG) developed in 2008, suggesting ≥ 150 minutes of moderate-to-vigorous PA a week. In contrast, 27% and 28% of women participated in 150–299 and ≥ 300 minutes per week of physical activity. Tobacco use was comparable among all injury type groups. Diagnoses of osteopenia and vision problems were most prevalent in subjects incurring PA-related MSIs (Table 1).

A total of 323 and 330 MSIs were reported during PA and non-PA events. Table 1 presents the frequency of baseline characteristics of each independent variable by MSI type. Women reporting MSI at baseline or previous injury were more likely to report subsequent PA-related and non-PA-related MSIs (Table 1). A greater percentage of participants with BMI $< 25 \text{ kg/m}^2$ reported no MSIs. Of those who did report a PA-related MSI, injury percentages increased as BMI categories decreased from obese to normal; however,

TABLE 1. CHARACTERISTICS OF SUBJECTS ACCORDING TO INJURY TYPE, THE WOMEN'S INJURY STUDY

	<i>At least one PA-related musculoskeletal injury (n = 246)</i>	<i>Only non-PA-related musculoskeletal injuries (n = 165)</i>	<i>No reported musculoskeletal injury (n = 498)</i>	<i>Total (N = 909)</i>
Age, years, mean (SD)*	55 ± 11.5	53 ± 11.7	51 ± 13.1	53 ± 12.5
Age group: ≥ 65 years old, n (%)**	39 (16%)	32 (19%)	78 (16%)	149 (16%)
Education level**				
< 12 years, n (%)	2 (1%)	0 (0%)	2 (1%)	4 (1%)
12–15 years, n (%)	75 (30%)	63 (38%)	173 (35%)	311 (34%)
16–19 years, n (%)	145 (59%)	91 (55%)	274 (55%)	510 (56%)
20+ years, n (%)	24 (10%)	11 (7%)	49 (9%)	84 (9%)
Ethnicity**				
White, n (%)	199 (81%)	132 (80%)	372 (75%)	703 (77%)
Black, n (%)	33 (13%)	29 (18%)	101 (20%)	163 (18%)
Other, n (%)	14 (6%)	4 (2%)	25 (5%)	43 (5%)
Current tobacco use, n (%)**	3 (1%)	4 (2%)	16 (3%)	23 (3%)
Current alcohol use, n (%)**	150 (61%)	94 (57%)	285 (57%)	529 (58%)
Osteopenia, n (%)**	66 (27%)	36 (22%)	103 (21%)	205 (23%)
Osteoporosis, n (%)**	48 (20%)	32 (19%)	78 (16%)	158 (17%)
Vision problems, n (%)**	204 (83%)	129 (78%)	391 (79%)	724 (80%)
Body mass index**				
None available, n (%)	1 (1%)	0 (0%)	0 (0%)	1 (1%)
Normal, < 25 kg/m ² n (%)	105 (42%)	48 (29%)	205 (41%)	358 (39%)
Overweight, > 25–29.9 kg/m ² n (%)	84 (34%)	56 (34%)	153 (31%)	293 (32%)
Obese, ≥ 30 kg/m ² n (%)	56 (23%)	61 (37%)	140 (28%)	257 (28%)
<i>Prior injury and physical activity history</i>				
Yes, n (%)	214 (87%)	138 (84%)	346 (69%)	698 (77%)
No, n (%)	32 (13%)	27 (16%)	152 (31%)	211 (23%)
Strength training, days per week during study, mean (SD)*,†	1 ± 1.6	0 ± 1.3	0 ± 1.4	0 ± 1.5
Aerobic activity during study, n (%)**				
< 150 minutes/week	87 (35%)	93 (56%)	230 (46%)	410 (45%)
150–299 minutes/week	71 (29%)	38 (23%)	135 (27%)	244 (27%)
≥ 300 minutes/week	88 (36%)	34 (21%)	133 (27%)	255 (28%)
Weekly pedometer steps reported during study × 10 ³ , mean (SD)*,†	47.3 ± 40.2	42.1 ± 34.6	45.8 ± 34.0	45.5 ± 36.1
Weeks of PA reported during study, mean (SD)*	99 ± 28.1	103 ± 27.5	83 ± 40	91 ± 36

*years, mean (SD)=years, mean (standard deviation).

**n (%)=number (percent).

†Average for non-injured weeks.

PA, physical activity.

non-PA-related MSIs increased as BMI increased among normal (< 25 kg/m²), overweight (25–29.9 kg/m²), and obese (≥ 30 kg/m²) participants at 29%, 34%, and 37%, respectively. Contrasted with the women who met PA guidelines, women who did not meet guidelines were more likely to incur PA- and non-PA-related MSIs; however, those who exceeded PA guidelines (≥ 300 minutes/week) had higher percentages of PA-related MSIs compared to those who met or did not meet PAG (Table 1).

The prevalence of injury coming gradually and (getting) worse with activity was 69% for PA MSIs versus 12% for non-PA-related MSIs (Table 2). The types of activities in which PA-related MSIs occurred most often included free-living walking (26%) and jogging (18%) activities. On the other hand, treadmill and bicycling were associated with the lowest percentage of PA-related MSIs, ≤ 1% (Table 3). The inciting cause for non-PA injury was not obtained as noted in the methods

section. Reported PA-related MSIs were generally minor and less likely to require treatment from health care providers (60% vs. 80%) and resulted in less initial reporting of missed days of work/school (11%) compared to non-PA MSIs (17%). Self-treatment of PA injuries included “other” (25%), over-the-counter medication (23%), application of cold (21%), application of heat (11%), use of external support (10%), application of topical cream (6%), nothing (3%), and assistive devices (2%). Treatment for non-PA-related injuries followed a similar trend, with “other” describing treatment method most often used (25%) and assistive devices used the least (2%). Self-treatment methods labeled as “other” required a wide variety of interventions; however, the vast majority of treatments required minimum medical intervention.

Figure 1 presents odds ratios (ORs) for injury sites related to PA versus otherwise, controlling for age, BMI, previous injury, and use of alcohol. Compared to non-PA related

TABLE 2. REPORTED MUSCULOSKELETAL INJURIES BY CAUSE*

	Physical activity musculoskeletal injury, n (%)	Non-physical activity musculoskeletal injury, n (%)
Came on gradually and got worse with activity	224 (69%)	41 (12%)
Colliding, tripping, or falling	51 (16%)	65 (20%)
Came on suddenly with no apparent cause	25 (8%)	178 (54%)
Contact by an object, person, or animal	17 (5%)	23 (7%)
Not meeting above criteria	5 (2%)	10 (3%)
Motor vehicle accident or other vehicular trauma	1 (0%)	13 (4%)
Total number of injuries	323	330

*Eight injuries from a total of three people could not be categorized due to insufficient data.

injuries, PA-related injuries were more likely to involve the lower (OR = 3.10, $p = 0.002$) or upper limbs (OR = 2.54, $p = 0.01$) and less likely to involve the head/jaw/neck (OR = 0.21, $p = 0.002$).

Discussion

Comparable absolute MSI rates, measured by self-report, were found among women who incurred PA- and non-PA-related injuries. However, there are some differences in mechanisms of injury, the distribution of injuries by anatomical location, and the treatment of injuries depending on aerobic activity participation. Non-PA-related injuries tended to be sudden in nature versus gradual, with external causes (i.e., contact by object, colliding, falling) accounting for 27% of injuries, while PA-related MSIs with external causes accounted for 21%. Further, rates of non-PA-related injuries requiring at

TABLE 3. TYPES OF ACTIVITIES IN WHICH PARTICIPANTS SUSTAINED PHYSICAL-ACTIVITY-RELATED MUSCULOSKELETAL INJURIES^a

Type of activity	PA MSI n (%)
Walking	83 (26%)
Jogging/running	57 (18%)
Weight training	30 (9%)
Household activities	24 (7%)
Aerobic dance/calisthenics/floor exercise	20 (6%)
Moderate/vigorous sports	19 (6%)
Lawnwork/gardening	15 (5%)
Stair climbing	9 (3%)
Swimming	5 (2%)
Missing response	6 (2%)
Bicycling	4 (1%)
Treadmill	1 (0%)
Other ^b	50 (15%)
Total	323 (100%)

^aUnit of analysis is injury.

^b"Other" was a total of 30 activities that included physical activities such as sit-ups, ice-skating, and kayaking.

MSI, musculoskeletal injuries.

FIG. 1. Site of injury odds ratios for physical activity-related injuries (versus nonphysical-activity-related injuries), controlled for age, body mass index, prior injury, and alcohol use.

least one visit to a health care provider was 18% more than PA-related MSIs. The results of this report suggest that the incidence of MSIs sustained during PA may be comparable to those sustained during non-PA-related behaviors; however, some differences in injury characteristics are evident.

Injury data generally show increased PA, defined by increased frequency, intensity, and duration, associated with increased risk of injury in military and community populations.⁸⁻¹⁰ However, substantial health benefits have been associated with increased PA and cardiorespiratory fitness levels.¹¹⁻¹³ Occurrence of injury in general populations attributed to PA has been relatively small in number and minor in nature.¹⁴ Carlson et al¹⁵ suggested all-cause injury incidence did not differ between active and inactive individuals. Further, inactive individuals had greater likelihood of being injured during non-sport and non-leisure activities compared to the active population. PA-related MSIs in our population, 49% of total injuries, are considerably higher than the National Health and Nutrition Examination Survey (NHANES) sports and exercise injury episodes estimated national average of 16.1%.¹⁶ Additional literature from NHANES has noted external causes such as falling as a significant contributor to intentional and/or unintentional injury for men and women, specifically during leisure.¹⁶ Conversely, Uitenbroek observed a relatively higher sports and exercise injury rate in the general population. However, in women, the highest injury rate occurred during non-PA-related behaviors such as work and travel (i.e., motor vehicle, foot).¹⁷ In addition, prior studies have shown variability in need for medical attention and hospitalization that appears to be based on type and intensity of the activity.¹⁴

Given the increase of public awareness concerning the risks and benefits associated with PA, it is essential to learn whether adopting or maintaining a physically active lifestyle increases risk or severity of MSI beyond that of daily living. Distinct differences in risk of MSI have been observed dependent on the intensity, frequency, and duration of PA participation in men and women.^{10,18} In our population, PA-related MSIs and non-PA-related MSIs variance in mechanisms and anatomical location may be related to substantial differences in intensity of

PA-related and non-PA-related behaviors during time of injury, although prevalence of MSI did not increase.

A major strength of our study includes a large cohort of community-dwelling women tracked for PA behaviors and injuries weekly for an extended period of time. Self-report injury incidences often require recall of the past month to year; however, weekly recall offers more accurate and reliable insight to injury occurrences. In addition, surveillance calls by trained personnel ensured injury type (PA- or non-PA-related) was classified according to standard procedures, which decreased misclassification due to a subject's misperception of injury type, cause, or location. In addition to the small number of "other injuries" reported, the type of activity being performed during non-PA-related MSIs was not reported. In addition, inaccurate recall of injury details could introduce error in the data. Since injury rates have been associated with exposure time, further detail including amount of time spent during specific PA could be more informative.

Conclusions

These data show that, among women, PA- and non-PA-related MSIs were comparable regarding absolute number, yet differed in relation to location of injury and mechanisms. PA behaviors did not seem to increase injury or consequences of injury (i.e., missed days of work/school) in our cohort of community-dwelling women. These results support that PA injury may not negatively impact quality of life or impact daily life activities beyond that of non-PA injuries. In sum, the relation between PA behaviors and health outcomes is evident in existing literature.¹ The results of this study show that in "real-world" women, the number and nature of significant MSIs during PA are not substantially different during PA than in non-PA activities. It is critical in this era of increasing sedentary behavior and obesity that PA counseling be part of routine preventive health care. Healthcare providers should consider the potential health-related risks of exercise and evaluate their patients as indicated prior to the beginning of a PA program. As recommended, nonexercisers should initiate their activity regimen gradually over weeks to months and optimally do a variety of activities to diminish overuse injuries.¹ Consistent with the American College of Sports Medicine's Exercise is Medicine™ campaign, healthcare providers should feel confident when discussing adoption and maintenance of PA behaviors that patients should not be adversely impacted by MSIs in a way that reduces the true health benefits of physically active lifestyles.

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Author Disclosure Statement

No competing financial interests exist.

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