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Impact of Concussion and Orthopedic Injuries on Physical Activity and Quality of Life after Sport Retirement

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IMPACT OF CONCUSSIONS AND ORTHOPEDIC INJURIES ON PHYSICAL ACTIVITY AND QUALITY OF LIFE AFTER SPORTS RETIREMENT

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This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABSTRACT

IMPACT OF CONCUSSIONS AND ORTHOPEDIC INJURIES ON PHYSICAL ACTIVITY AND QUALITY OF LIFE AFTER SPORTS RETIREMENT
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CONTEXT: Concussions and orthopedic injuries represent a significant risk related to participation in collegiate athletics. These injuries can create significant long-term impairments and functional limitations which may also decrease former athletes' quality of life (QoL) and inhibit their ability to engage in physical activity.

OBJECTIVE: To investigate QoL and physical activity levels of former collegiate athletes with a history of concussion and orthopedic injury, orthopedic injury only, and healthy controls.

DESIGN: Descriptive, experimental study.

SETTING: Daily life as former National Collegiate Athletic Association Division I collegiate athlete.

PARTICIPANTS: Former Division I collegiate athletes competing in football, women's soccer, baseball, softball, and women's track with no history of injury or a history of concussion or orthopedic injury.

INTERVENTION(S): Participants completed the Short Form 36 version 2 (SF-36v2) quality of life questionnaire and the International Physical Activity Questionnaire (IPAQ).

MAIN OUTCOME MEASURE(S): Differences in QoL and physical activity between participant groups, along with the association between QoL and physical activity, were assessed.

RESULTS: There were no significant differences in overall quality of life between the CON/OI, OI, and HC groups. Significant differences were found between the CON/OI and HC groups on the role physical subscale. Significant differences were found between the OI and CON/OI groups on the general health subscale and overall physical health. There were no significant differences in reported physical activity levels between CON/OI, OI, and HC groups, nor any association between physical activity and QoL. CONCLUSIONS: Injury history has minimal impact on QoL in former Division I athletes between the ages of 23 and 32 years. These results suggest that decreases in QoL that former athletes may experience are most likely to develop well after cessation of competitive sport participation.

KEY WORDS: concussion, orthopedic injury, quality of life, physical activity, former athlete.

INTRODUCTION

Over 36 million youth between the ages of 5 and 18 participated in organized sport in 2017, with nearly 8 million sanctioned high school sport participants.[1-3] Similarly, collegiate sport participation is extremely high, with a 19% increase in participants over the last 10 years. The National Collegiate Athletic Association (NCAA) recently reported nearly 500,000 participating student-athletes.[4]

Collegiate athletes in particular assume a high risk of injury through sport participation. Data indicates that over 200,000 injuries occur to NCAA student-athletes on an annual basis, with injury rates varying between genders, sport, and practice versus competition settings.[5,6] The nature of these injuries varies widely. Nearly 11,000 concussions, representing over 6% of all reported injuries, occur on an annual basis.[7,8] Orthopedic injuries similarly represent a significant risk associated with collegiate sport participation. In a single NCAA Division I football team, a total of 234 orthopedic surgeries were performed over a 10 season time period.[9] Unfortunately, injuries requiring surgical intervention represent a small fraction of the total number of injuries sustained; between 2009-2014, 1,142 hamstring strains were reported across 25 NCAA sports.[10]

Evidence suggests that sport-related injury can result in significant long-term impairments and functional limitations. Memory impairment, depression, hypopituitarism, and fatigue appear to be associated with a history of concussion.[11-15] Orthopedic injuries, meanwhile, can increase an individual's risk for osteoarthritis and mental health sequelae, limit mobility, and increase the likelihood of long-term pain.[16-18] Interestingly, athletic participation places stress on the body that may also predispose

individuals to future injuries and diseases, even if they have no history of injury from their sport participation.[19-21]

Sport-related injury may also decrease participants' quality of life (QoL). While research has shown that current athletes report better overall QoL than non-athletes, injured athletes did report lower QoL than those who were uninjured.[22] Moreover, although contrasting findings exist,[23] sport-related injury has been shown to negatively influence QoL in former athletes who reported lower QoL than non-athletes.[19] Findings from other research also indicate that the nature of injury[24,25] as well as type of sport may impact QoL, with lower QoL linked to athletes from collision sports.[26]

Additionally, studies have indicated that former college athletes experience increased limitations in their daily lives which may impact their ability to exercise.[19,22,26] When comparing athletes to age and sex-matched controls, Friery et al found that 21% of the athletes reported limitations in daily living caused by injuries sustained during college athletics, and 36% reported limitations during exercise.[27] While studies investigating physical activity levels reveal a slight trend indicating that former athletes participate in a greater amount of moderate physical activity when compared to the general population,[28,29] less than 60% of former athletes participate in the minimal amount of physical activity suggested by the Surgeon General.[28,30]

The likelihood of sustaining an injury through college sport participation, the effect of sport-related injury on physical activity and QoL, and the scarcity of information linking these elements necessitates further investigation.[24,25,27] Therefore, the first purpose of this study is to investigate QoL of former collegiate athletes with a history of concussion and orthopedic injury (CON/OI), those with a history of orthopedic injury

(OI) only, and uninjured/healthy control (HC) former athletes. We hypothesize that participants in both the OI and CON/OI groups will report lower QoL compared to HCs. We also hypothesize that the CON/OI group will score lowest among groups on mental health. The second purpose of this study is to investigate physical activity levels of former collegiate athletes. We hypothesize that the CON/OI and OI groups will report lower physical activity levels compared to the HC group. The final purpose of this study is to identify differences in QoL among former athletes based on physical activity levels. We hypothesize that individuals that report greater amounts of physical activity will report higher QoL scores regardless of injury history.

Research Questions

This investigation of quality of life and physical activity in retired collegiate athletes is based on the following primary questions:

1. In retired collegiate athletes, how does quality of life differ between individuals with:
    a. No history of injury
    b. History of orthopedic injury
    c. History of concussion and orthopedic injury
2. In retired collegiate athletes, how does daily physical activity differ between individuals with:
    a. No history of injury
    b. History of orthopedic injury
    c. History of concussion and orthopedic injury

3. How do physical activity levels influence QoL in retired collegiate athletes with:
    a. No history of injury
    b. History of orthopedic injury
    c. History of concussion and orthopedic injury

METHODOLOGY

Participants

Participants in this study (n=36) were male and female former student-athletes who participated in either football, women's soccer, women's volleyball, baseball, softball, and women or men's track and field at an NCAA Division I university between the years of 2007-2014. All participants were between the ages of 18-24 during the time of their collegiate athletic careers. Participants included individuals who reported a history of a physician-diagnosed concussion as well as orthopedic injury (CON/OI; n=12), orthopedic injury only (OI; n=12), and healthy controls (HC; n=12). An OI was defined as a bone, ligament, muscle, or tendon injury, or structural malalignment, that was sustained due to athletic practice or competition, was diagnosed by an athletic trainer or physician, and that resulted in time loss greater than one day.[31,32] Healthy control participants were defined as those who did not report a history of either orthopedic injury or concussion. A total of 147 participants were initially eligible for participation in this study based on their self-reported injury history. All participants were matched based on gender and injury severity based on time loss, resulting in a final pool of 36 participants. Injury severity was categorized as mild (1-7 days), moderate (8-28 days), and severe (greater than 28 days).[33-34]

Instrumentation

The Short Form 36 version 2 (SF-36v2) quality of life questionnaire and the International Physical Activity Questionnaire (IPAQ) were utilized in this study.

The SF-36v2 is a quality of life questionnaire that has been validated and widely used with multiple conditions including orthopedic injuries and concussions.[23,26,35]

The 11-question instrument comprised of 8 subscales uses a Likert scale to assess participants' views about their health, how they feel, and how well they can perform their usual activities based on the past 4 weeks. Subscales include physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health which allow for analysis of an individual's overall QoL as well as physical and mental health. General health is measured with questions such as "How true or false is the following statement for you: I am as healthy as anybody I know." Physical health, a composite of physical function, role physical, bodily pain, and general health, is measured with questions such as "Does your health now limit your ability to perform moderate activities such as moving a table, pushing a vacuum cleaner, bowling, or playing golf, if so how much?" and "During the past 4 weeks how much did pain interfere with your normal work (including both work outside the home and housework)?" Mental health, a composite of vitality, social function, role emotional, and mental health, is measured with questions such as "How much of the time during the past 4 weeks did you feel full of life?" and "During the past 4 weeks how much time have you had to cut down on the amount of time you spent on work or other activities as a result of any emotional problems (such as feeling depressed or anxious)?" Research indicates that the SF36v2 regularly exceeds the minimum recommended 0.70 reliability coefficient standard when used in group comparison studies while the physical and mental summary scores typically exceed 0.90.[36]

The International Physical Activity Questionnaire - Long Form (IPAQ) was used to measure participants' level of physical activity. The IPAQ represents the most widely used physical activity questionnaire and includes all forms of physical activity that are

applicable to this population (work, home, transportation, and recreational). The IPAQ consists of 27 questions and measures the duration and frequency of activities performed based on a seven-day recall. In young to elderly adults, this instrument has demonstrated strong reliability and sufficient content validity due to its discernment between the varied settings in which physical activity occurs.[36-38]

Procedure

Institutional Review Board approval (IRB-1807006-EXM) was obtained prior to the collection of any data. Participants in this study were identified through a review of the University's Sports Medicine Department Sports Injury Management (SIMs) database. Medical documentation maintained within the SIMs database for all student-athletes at this institution from the past 7 years was reviewed to identify patients with a history of concussion or orthopedic injury, as well as healthy controls. Once identified, eligible participants were randomized within their respective groups and then matched according to gender, age, and injury severity based on time loss. Participants were then contacted via electronic mail to explain the nature of the study and seek informed consent. Participants who consented to participate continued by completing both questionnaires in electronic format. After 2 weeks, participants who did not respond to the original email were contacted a second time in an effort to solicit their participation. Participants who did not respond after the second electronic mail were contacted via telephone to explain the study, gain consent, and complete the questionnaires with the principal investigator reading the questions and documenting the participants' responses.

Completed questionnaires were kept in a locked cabinet to which only the principal investigator had access.

Data Analysis

Participant characteristics are given as tabulations for each of the variables of interest with the exception of age which is given as mean and range. Comparisons of mean outcome scores for each of the outcome scores were assessed using analysis of variance adjusting for age and socioeconomic status. Due to the 3 groups being compared, post-hoc analyses were performed using Tukey's HSD with alpha=0.05. MET-minutes and sitting time were compared among groups and were analyzed in a similar fashion to the mean outcome scores. Finally, chi-square analysis was performed to determine if the distribution of individuals in each of the physical activity categories varied among the 3 groups.

RESULTS

Descriptive statistics

A total of 147 individuals were invited to participate in this study. Individuals with a history of orthopedic injury (OI) or concussion and orthopedic injury (CON/OI), as well as healthy controls (HC), were paired based on gender, age, and time loss due to injury. Overall, 36 participants (OI=12; CON/OI=12; HC=12) were paired and included in this study. Each group was represented by 5 males and 7 females. Among each injury group (OI and CON/OI), 9 participant pairings reported a history of moderate injury (time loss 7-30 days) while 3 participant pairings reported a history of severe injury (time loss 31 days or longer). Participant age, marital status, family income, and highest level of education are indicated in Table 1.

Table 1. Participant Characteristics

	CON/OI	OI	HC
Number	12	12	12
Age (years)	25.6 [23-29]	25.3 [23-27]	26.7 [23-32]
Marital status			
Single	4	7	5
Married	8	5	7
Family income			
$40,000-$59,999 or less	3	2	1
$60,000-$99,999	4	2	4
$100,000 or more	2	2	3
Individual income			
$40,000-$59,999 or less	9	11	10
$60,000-$99,999	2	1	2
$100,000 or more	1	0	0
Education level			
Bachelor's degree	6	10	10
Master's degree	5	2	1
Doctoral degree	1	0	1

Quality of Life and Injury History

Total scale, physical and mental composite, and subscale scores (mean ± standard deviation) for the SF36v2 are reported in Table 2. Healthy controls reported significantly higher role physical subscale scores as compared to CON/OI participants, while general health subscale scores were significantly higher in OI versus CON/OI participants. Overall physical health was significantly better in OI participants versus those with a history of concussion and orthopedic injury.

Table 2. Mean Outcomes Scores from SF36v2

	CON/OI	OI	HC
Health-related quality of life	128.3 ± 5.1	142.6 ± 4.6	135.9 ± 4.7
Subscale			
Physical function	27.7 ± 0.6	29.7 ± 0.6	29.9 ± 0.6
Role physical	17.4 ± 0.8[a]	19.4 ± 0.7	19.5 ± 0.7[a]
Body pain	9.1 ± 0.6	9.3 ± 0.6	9.8 ± 0.6
General health	18.3 ± 1.0[a]	21.3 ± 0.9[a]	19.6 ± 0.9
Vitality	12.5 ± 1.1	14.7 ± 1.0	13.3 ± 1.0
Social function	8.7 ± 0.5	9.4 ± 0.5	8.5 ± 0.5
Role emotional	13.1 ± 0.7	14.3 ± 0.7	13.1 ± 0.7
Mental health	18.6 ± 1.1	20.2 ± 1.0	20.9 ± 1.0
Composite			
Physical health	73.1 ± 10.2[a]	79.8 ± 4.4[a]	78.7 ± 4.8
Mental health	53.5 ± 10.4	58.2 ± 8.0	55.7 ± 8.7

Variables within rows labeled with the same superscript are different at $p<0.05$ after adjusting for age and socioeconomic status using a Tukey's HSD test.

Physical Activity and Injury History

There were no significant differences in physical activity levels between the CON/OI, OI, and HC participants (Table 3). Similarly, there were no significant differences found in the amount of time spent sitting between the groups. Physical

activity levels were not associated with overall QoL, physical or mental health, or any of the subscale scores identified in Table 2.

Table 3. Physical Activity Levels

	CON/OI	OI	HC
MET-Minutes	7,373 ± 2,340	6,617 ± 2,141	10,413 ± 2,156
Category			
Low	2	0	0
Moderate	2	5	4
High	8	7	8
Sitting Time	340 ± 131	290 ± 99	368 ± 190

Physical activity levels were not associated with any of the outcomes listed in Table 2.

DISCUSSION

Quality of Life

To our knowledge this is the first study comparing the QoL of former student-athletes that have reported a history of concussion and orthopedic injury versus those with a history of orthopedic injury only, or who were uninjured. With respect to quality of life, our results revealed significant differences between the CON/OI and HC groups on the role physical dimension, and the CON/OI and OI groups on general health. These findings could be explained by the nature of sport involvement among participants in the CON/OI group. While we did not control for this, concussive injuries are more common in contact sports.[26,40] Moreover, research suggests that contact or collision sports may lead to more cumulative impacts that may eventually decrease general health or the ability to engage in daily functional tasks.[26,40] Despite this, there were no significant differences in overall QoL between the participant groups. This contradicts our hypothesis that participants with a history of orthopedic injury, or concussion and orthopedic injury, would report lower overall QoL compared to those with no injury history. Both Houston et al[22] and Brooks[42] found significantly lower health-related quality of life and/or greater daily and physical activity limitations in injured versus non-injured athletes. The lack of significant difference in QoL between groups in our study could be explained by the relatively young age of the participants and the fact that QoL deficits become more common with advancing age.[23,26-27,51-54]

Although we found no between-group difference in overall QoL, our results did indicate that OI group participants reported significantly greater overall physical health than participants in the CON/OI group. This suggests that the CON/OI participants

experienced greater limitations in type or time spent doing activities, greater difficulty performing activities, and an inability to accomplish what they would like due to their physical functioning and symptoms. Our finding of lower physical health in the CON/OI group aligns with findings from Simon and Docherty[26] and could be related to participants' sport contact level. Simon and Docherty found that former NCAA Division I athletes from collision sports reported lower health related quality of life when compared to contact and contact-limited athletes.[26] Kerr and colleagues' study of 797 former college athletes provides additional support, where athletes that reported a history of 3 or more concussions, that played a collision sport during college, and who sustained a career-ending injury reported lower physical health scores.[40] A majority of concussions occur in sports that are classified as contact or collision, thus, ongoing physical impairments experienced by former collision sport athletes may not be due exclusively to having sustained a concussion but also the physical nature of the sport in question. Regardless, a comparison of sport contact level was not a focus of this study.

Additionally, lower physical health in the CON/OI compared to OI group could suggest a cumulative effect of injury, as prior research suggests that a higher number of injuries experienced can lead to lower physical health and quality of life.[41-43] However, there was no significant difference between the OI and HC groups on physical health. Thus, additional factors such as post-retirement changes in health status, especially among HC participants, could also explain our physical health findings. Finally, our physical health findings could potentially be related to an insufficient injury rehabilitation process. For example, an athlete that sustained a concussion caused by a whiplash mechanism may have also sustained a simultaneous orthopedic injury such as a muscle

strain or malalignment of the spine. A failure to address the impairments associated with this type of orthopedic injury due to overshadowing by the concussive injury could explain the better physical health scores in the OI compared to the CON/OI group.

Interestingly, there was no significant difference in overall mental health between any of the participant groups. This finding contradicts existing literature as well as our second hypothesis that participants with a history of CON/OI would report lower mental health than that of the OI or HC participants. In a longitudinal study of 1,044 retired NFL players, Kerr[44] found an association between a history of concussion and risk of being diagnosed with depression within the following 9 years. Only 3% of non-concussed athletes reported a diagnosis of depression, while athletes that reported a history of 1 or 2 concussions were 1.5 times as likely to be diagnosed with depression compared to controls. A history of 3 or more concussions increased depression risk by 3 times. Similar findings related to depression and a history of concussion have been identified in both rugby players and boxers.[45,46] Interestingly, most of the aforementioned studies were performed on retired sport participants whose last reported concussion injury occurred over 10 years earlier. Participants in our study represent recent college graduates whose last reported concussion occurred within the last 7 years. This difference in time from the last reported concussion could be a potential explanation for the lack of significant difference in mental health between the CON/OI and the OI or HC groups. Another potential explanation is that our CON/OI group was comprised of athletes from a mix of contact and non-contact sports. A majority of the current literature related to post-concussion mental health has focused on high contact level sports such as football, rugby, and boxing, all of which expose participants to repeated sub-concussive

impacts. Recent studies investing the cumulative effect of sub-concussive impacts reveal a positive association with neurodegenerative pathology, suggesting that accumulated sub-concussive impacts are equally as important as concussion history when investigating degenerative pathology and cognition.[47-50] Our inclusion of sports that range in contact level, and thus prevalence of sub-concussive blows, could explain why the CON/OI group did not present with a decline in mental health. Finally most of the participants in our study reported a history of a single concussion with none reporting more than 2 during their athletic career; this too could explain the lack of difference in mental health between participant groups.

Physical Activity

We also hypothesized that physical activity levels would be significantly lower among the CON/OI and OI group participants compared to those in the HC group; our results did not support this supposition. Current literature indicates that the relative risk of developing osteoarthritis (OA) increases between 3.5 and 5.17 times in people who have a history of joint injury.[52] Gelber et al[52] found that by age 65, participants with a history of joint injury that occurred during childhood or adolescence exhibited an incidence of OA of 13.9% compared to 6% in participants who did not have a history of joint injury. Our results also contradict Friery and colleagues[27] who found that 36% of former college athletes reported limitations in physical activity as a result of an injury sustained during college athletics. However, the average age of participants in Friery et al[27] was 41.1 years old compared to 25.5 years in this study. Much of the available literature on physical activity in former athletes focuses on older age groups.[23,26,51-56] As such, it's possible that our population was too young to begin having symptoms

associated with chronic diseases related to a history of injury such as osteoarthritis, cartilage degeneration, joint pain, depression, or cognitive impairments, all of which may be more likely to develop later in life.[51-56]

Finally, our results indicated that there was no association between physical activity levels and quality of life. This finding disproves our hypothesis that individuals that report greater amounts of physical activity would report higher QoL scores regardless of injury history. Furthermore, our results contradict current literature indicating that physical activity has a positive impact on QoL.[55-58] Gill et al found that physical activity contributes to all aspects of QoL and that the social and emotional benefits of physical activity are also motivators to continue physical activity.[55] Pucci also found that individuals that perform 150 or more minutes of moderate intensity physical activity each week reported a QoL score 5.3 points higher than those who don't.[56] Regardless, the lack of an association between physical activity and QoL may be explained by the small sample size in our study. Moreover, given the multi-dimensional nature of QoL, our results could indicate that participants in our study were experiencing a variety of additional factors that could add or detract from their perceptions of this construct.

LIMITATIONS

There were 36 total participants with 12 per group in this study, thus, sample size could have impacted our results. All of the participants in this study were from the same Division I NCAA institution, therefore, the results of this study may not be representative of all college athletes. Additionally, the average age of participants in this study was less than 26 years. As such, participants in this study largely represented recent graduates

who may not yet be experiencing symptoms of potential future pathology such as osteoarthritis. Our study did not account for recurrent or total number of orthopedic or concussion injuries sustained during their college career, nor did we stratify individuals whose injuries resulted in surgical intervention versus conservative treatment. Furthermore, this study used fairly non-specific, albeit referenced, time loss categories (7-30 days or 30 days or longer). Thus, individuals that lost over 4 months were placed in the same category as individuals that took 4 weeks to return to practice and competition. In light of this, future studies should further stratify individuals based on the nature of injury, treatment method, and more specific time loss categories. Our study relied heavily on honesty of answers and accuracy of documentation which could have impacted our results.

CONCLUSIONS

Research has shown that sport-related injuries and athletic participation can lead to long-term impairments and functional limitations such as depression, fatigue, memory impairment, limited mobility, pain, and osteoarthritis, all of which can negatively influence QoL and physical activity levels.[11-21] Contrary to findings from older generations of athletes, our results suggest that recent college graduates with a history of sport-related injury largely do not experience impairments or functional limitations that decrease physical activity levels or QoL any more so than non-injured athletes.[23,26,51-56]

Based on our results and existing research, sports medicine professionals should consider implementing educational sessions focused on healthy lifestyle habits after athletic retirement. Educational topics should include healthy dietary habits, benefits of physical activity, weight management, and strategies for pain management. A discussion

on these topics may help former athletes reduce their risk of developing chronic diseases or maintain a high quality of life. Future research efforts should examine the impact that pre-retirement educational sessions may have on lifelong healthy lifestyle habits. Furthermore, investigations into the QoL of former college athletes should attempt to control for contact level of sport while examining the longitudinal impact of concussions and orthopedic injury on physical activity.

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