5-15-2021

The Role of Pre-Season Health Characteristics as Injury Risk Factors in Female Adolescent Soccer Players

Brent Harper

Adrian Aron

Emmanuel John

J. Phys. Ther. Sci. 33: 439–443, 2021

The Journal of Physical Therapy Science

Original Article

The role of pre-season health characteristics as injury risk factors in female adolescent soccer players

Brent Harper[1)*], Adrian Aron[2)], Emmanuel John[1)]

1) Department of Physical Therapy, Crean College of Health & Behavioral Sciences, Rinker Health Science Campus in Irvine, Chapman University: 9401 Jeronimo Rd, Irvine, CA 92618, USA
2) Department of Physical Therapy, Radford University, USA

Abstract. [Purpose] Determine if female adolescent soccer players with a history of concussion, impaired K-D scores, and pre-season subjective complaints of neck pain, dizziness, and headache were predisposed to additional risk of musculoskeletal or concussive injury during 10-weeks of competitive play. [Participants and Methods] Twenty-three female high school soccer athletes provided concussion history and reported pre-season subjective complaints. K-D testing was performed pre and postseason. During the 10-week season, all injuries, preventing participation in practice or game, were recorded. [Results] Six reported a history of concussion. Of those six, three injuries were reported, including two concussions and a hamstring strain. Baseline K-D scores were worse in athletes that had two or more pre-season subjective factors compared to those that did not have any. Moderate positive correlations were found between a history of concussion and the number of injuries and a history of concussion and K-D post-test scores. [Conclusion] Findings indicate that pre-season subjective factors of neck pain, dizziness and headache, history of concussion, and K-D potentially increased injury risk. Combining pre-season metrics both at baseline and during the course of the season may assist in better injury risk screening in-season or indicate suboptimal function due to cumulative effects.

Key words: Concussion, Female, Soccer

(This article was submitted Jan. 8, 2021, and was accepted Feb. 27, 2021)

INTRODUCTION

Soccer is the most widely played sport in the world and is popular among high school athletes[1)]. In the United States, there are an estimated 3.5 million registered youth soccer players between the ages of 5 and 19[1)]. Soccer is considered a moderate-to-high intensity sport in which athletes are susceptible to sustain injuries from various contact and noncontact forces[2)]. Contact forces include player-to-player and player-to-ball, while noncontact forces may include running, pivoting, landing, and cutting[2)].

Within the youth population, female athletes are twice as likely to suffer an injury, either musculoskeletal or concussive[1)]. The reason females are at increased risk of injury is not clear. Hypotheses include differences between head and neck musculature strength and stability, general anatomical variations of the brain between genders, and increased hormonal levels during menstrual cycle[3–6)]. The most common musculoskeletal injuries involve the lower extremity with ankle sprains comprising 16% to 29% and knee injuries 7% to 36%[2)]. In 2017, it was reported that concussions accounted for 15% of the total injuries sustained in high school athletics[7)]. Musculoskeletal and concussive injuries can be attributed to both extrinsic and intrinsic factors. Extrinsic factors refer to surface type, playing time, and equipment while intrinsic factors can include fitness level, flexibility, strength, biomechanics, balance, and proprioception[8)].

*Corresponding author. Brent Harper (E-mail: brharper@chapman.edu)

Recent studies have revealed that previous concussions predispose athletes to new concussion episodes[1, 9, 10]. A few studies have shown that one or more prior concussion increases the risk for concussive injury, improving the odds for the athlete to 5.8 times more likely to suffer another concussion[9, 10].

Concussions result in changes in mental status, and cause confusion, headache, dizziness, and neck pain[11, 12]. Neurological side effects from concussions can lead to impairments of vision, balance, proprioception, delayed reaction time, and impaired mental processing lasting up to weeks or months[13]. Once overt concussion symptoms have resolved, lingering deficits can manifest as subtle postural impairments and diminished neuromuscular control leading to the development of unconscious compensatory movement patterns[8, 14]. Throughout a sports season, these new patterns can become habitual, leading to an overall dysfunctional movement pattern with decreased mobility and stability, further predisposing an athlete to musculoskeletal injury[8]. This idea has been recently tested and it was found that a previous concussion can predispose an athlete to an increased risk of sustaining a musculoskeletal injury[15, 16].

Over the past few years, objective neurocognitive testing has become a standard for assessing the neurologic deficits related to concussions for return-to-play decisions[14]. A practical test is the King Devick (K-D), a commonly used concussion sideline pre and post screening tool that analyzes rapid eye movement[17, 18] and compares results to provide individualized assessment[18]. Despite a learning effect[19], the K-D has a sensitivity of 86% and specificity of 94%, and has been considered a valid, objective instrument to identify those needing further concussive workup[17, 20].

Objective metrics are useful to verify the presence or absence of symptoms, however, assessing athletes at risk for injury should also include subjective variables. Recent studies have suggested an association between subjective factors and concussion, and between poor performance on the K-D or balance impairments and increased risk of injury[8, 12, 17, 20]. As yet, research has not examined the utility of a screening tool which combines subjective and objective metrics to assess for increased in-season injury risk. The purpose of this study was to determine if female adolescent soccer players with a history of concussion, impaired K-D scores, and pre-season subjective complaints of neck pain, dizziness, and headache were predisposed to additional risk of musculoskeletal or concussive injury during 10-weeks of competitive play.

PARTICIPANTS AND METHODS

Twenty-three (16.0 ± 1.4 years) volunteer female varsity soccer athletes ages 14 to 18 from a public high school, were recruited into this study. Each participant and their parent or guardian completed and signed written informed consent and HIPAA agreements to allow researchers to use their personal health information. The study was approved by the University's Institutional Review Board (FY15-047). The participants also completed a Physical Activity Readiness Questionnaire (PAR-Q) to determine proper activity clearance by answering seven yes/no questions regarding heart conditions, chest pain, loss of balance, musculoskeletal problems, and medication side effects. Participants would have been excluded based on failure to obtain consent, answering "yes" to one or more PAR-Q questions, and if any surgery was performed within the last three months.

The participants completed an intake questionnaire consisting of demographics, self-reported history of concussion, prior musculoskeletal injury, and current health status. The current health status section assessed for pre-season complaints of headache, neck pain, or dizziness. For each of these factors, the frequency per week and severity, rated mild to severe, were noted. Dizziness was further analyzed by recording whether the symptoms occurred with movement or at rest.

Before data collection, researchers developed a script to provide consistent verbal instructions during the examination periods. Data was collected before and after a competitive season of 15 games over ten weeks. The researchers first obtained anthropometric data, including height and weight; followed by the K-D test performed according to manufacturer's recommended guidelines[21–23]. The K-D test required the participants to read a series of numbers from three separate cards as fast as possible without errors. The participants completed the test twice, and the researcher recorded the better of the two trials as the final score. The test was performed in front of a blank wall to limit visual distractions for the participants. Additionally, the number of injuries were noted by the coaches and athletic trainers throughout the season and then recorded by the researchers. Injuries were defined as a loss of body function or pain preventing athlete participation in a practice session or in a game[24]. Athletic exposure (AE) rate[25] as defined as one athlete participating in one practice or competition and was used to calculate incidence rate.

All data was analyzed using SPSS Statistics Version 22 (Armonk, NY, USA), with an alpha level set a priori at 0.05 for statistical significance. Before any data was analyzed, the normality of the data was assessed using the Shapiro-Wilk test. A Spearman correlation test was used between subjective history complaints and number of injuries. Two groups were formed based on the presence of the subjective factors. Those in the Symptomatic Group had a history of at least two factors, while those in the Non-symptomatic Group reported no history of any factors. Multiple independent t-tests were used to determine the differences in K-D scores between the groups formed based on pre-season symptoms of dizziness, headaches, neck pain and history of concussion.

RESULTS

A total of 23 female high school soccer players completed a 10-week season. Demographics of the athletes are highlighted in Table 1, while pre-season subjective complaints are displayed in Fig. 1.

A total of three athletes suffered injuries during the season, confirmed by the certified athletic trainer; injuries included one hamstring strain and two concussions. Moderate, positive correlations were found between history of concussion and number of injuries (p=0.008), and history of concussion and K-D post-test scores (p=0.047). Correlation findings are presented in Table 2. Independent t-tests yielded significant findings for analyzing baseline K-D scores in seconds and pre-season complaints of dizziness (M=41.6, SD 4.5, M=48.8, SD 9.2, p=0.034); post-test K-D scores with pre-season complaints of neck pain (M=42.9, SD 4.5, M=33.1, SD 0.00, p=0.047) and history of concussion (M=41.4, SD 4.4, M=47.4, SD 5.2, p=0.049). The means for baseline K-D test scores among players with a history of at least 2 subjective factors and those without a history are displayed in Table 3.

DISCUSSION

The current study demonstrated a moderate, positive correlation between a history of concussion and the number of injuries during the season (r= 0.600, p= 0.008). This supports the study's hypothesis that a history of concussion can be a factor used to identify potential athletes at risk for further injuries. A history of concussion has been associated with neurocognitive deficits and with impairments of the motor and supplemental cortices, affecting the athlete's ability to properly plan and incorporate practical motor skills, which are necessary for sports competition[9, 15]. Current research[9, 15] speculates that post-concussion deficits could include balance impairments, decreased ability to motor plan, and altered movement strategies, which may increase athletes' risk of sustaining a lower extremity injury[9, 15].

Our findings, in conjunction with others[9, 15], support the need to accurately identify suspected concussions or athletes

Table 1. Demographics of female high school soccer players

Variables	Means ± SD
Age (years)	16.0 ± 1.4
Height (cm)	165.2 ± 5.5
Weight (kg)	58.1 ± 5.5
BMI (kg/m^2)	21.3 ± 1.9

SD: Standard Deviation; BMI: Body Mass Index; cm: centimeters; kg: kilograms.

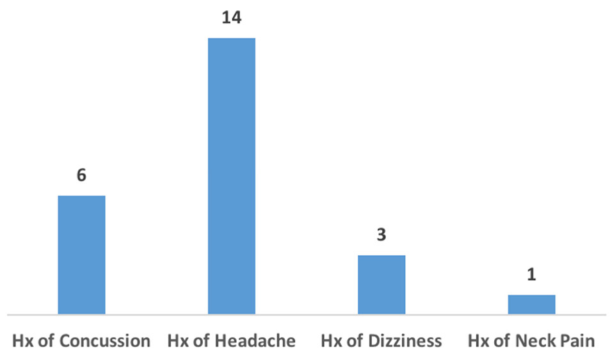

Fig. 1. Number of athletes with reported pre-season subjective complaints.

Table 2. Spearman correlations for number of injuries and history of concussion with other assessment measures

	Number of injuries	History of concussion
Number of injuries	-	r=0.600, p=0.008
History of concussion	r=0.600, p=0.008	-
History of headache	r=−0.182, p=0.485	r=0.039, p=0.865
History of neck pain	r=−0.108, p=0.668	r=−0.127, p=0.565
History of dizziness	r=−0.158, p=0.531	r=−0.230, p=0.291
K-D baseline test	r=0.302, p=0.224	r=0.149, p=0.497
K-D post-test	r=0.244, p=0.329	r=0.474, p=0.047

K-D: King Devick.

Table 3. K-D baseline scores based on presence of history of subjective factors

Groups	Mean KD baseline ± SD (sec)
Symptomatic	44.50 ± 8.04
Non-symptomatic	40.39 ± 3.61

K-D: King-Devick; sec: seconds.

presenting with concussion-like symptoms in order to provide interventions to decrease the risk of musculoskeletal injuries. These neuromuscular deficits should be appropriately treated using interventions to address the proprioceptive, vestibular, and somatosensory systems to normalize postural stability and oculomotor function.

Perhaps the K-D should be performed intermittently throughout the playing season to identify athletes requiring further assessment. Additionally, an established K-D score threshold may help identify athletes with subtle disturbances in their visual systems. Finally, a questionnaire should be provided postseason to assess the presence and chronicity of subjective complaints compared to pre-season complaints.

The current study evaluated how subjective pre-season measures and objective testing can be used to predict the risk of injury in a team of high school athletes. There were no significant findings among baseline subjective measures and the number of injuries occurred. Although there is limited research analyzing subjective measures and their ability to predict injury, recent literature has associated subjective measures with an increased risk for concussion[12)]. For instance, in a study by Schneider and others, with over 3,800 adolescent male ice hockey players between 11 to 14 years of age, baseline pre-season reports of neck pain or headache had 1.48 to 1.69 times increased risk of experiencing a concussion during the season while those reporting any two of three symptoms pre-season (e.g., neck pain, headache, or dizziness) were 1.99 times more likely to have an in-season concussion[12)]. Their study[12)] differs from our study as it did not assess the relationship between subjective reports with objective metrics and risk for musculoskeletal injuries and did not utilize the K-D test to screen for risk of injury. The K-D baseline scores in our study were different between athletes with and without a history of dizziness (41.6 ± 4.5, 48.8 ± 9.2, p=0.034). There was also a statistical difference in K-D postseason scores (42.9 ± 4.5, 33.1 ± 0.00, p=0.047) between the groups according to history of neck pain versus no history of neck pain. Although this information alone does not promote the hypothesis, it lends to support the theory that subjective pre-season measures may indicate suboptimal cortical function, specifically within the oculomotor system, which may be objectively assessed by the K-D[14)]. Such deficits in cortical performance may potentially alter the athlete's movement patterns and place them at higher risk for injury[8, 14)].

The current study utilized the K-D test as a way to objectify saccadic eye movement and cognitive function in athletes in order to help identify athletes at risk for injury. Currently, there is no conclusive evidence on whether a history of concussion correlates to K-D performance. However, a study by Bernstein and colleagues, found that latent symptoms of concussions lasting up to 60 days affected K-D scores in adolescent football players[26)]. Our study found that post-season K-D post-test scores were significantly associated with a history of concussion. Six athletes reported a history of concussion, with three athletes experiencing worse scores with the post-season K-D post-test, and another two suffering a concussion within the study playing season.

Subconcussive impacts have been defined as brain insults with insufficient force to cause acute signs and symptoms of a concussion[27)]. Such repetitive input or blows may manifest as subtle deficits including poorer K-D performance, persistent or current symptoms (i.e., neck pain, headache, or dizziness), or a previous concussion history may place an individual at risk of sustaining a concussion or attributed to the effects of multiple minor head impacts during competition leading to unrecognized head trauma[27, 28)].

It is reported that as many as 70% of concussed soccer athletes are unaware that they have suffered a concussion[1)]. In the current study, one athlete had a worse K-D score postseason from baseline but did not have a diagnosed concussion. Thus, it is essential to properly screen athletes with further balance and concussion tools to ensure there was not a missed diagnosis. Prior research identified that subjective reports may predispose individual to future injury[29)] and that K-D testing could identify those exposed to forces that may result in a concussion[30)]. In our current study the raw data identified that in the presence of 2 out of 4 pre-season subjective measures (history of concussion, pre-season headache, dizziness, and neck pain), K-D scores at baseline were 4.1 seconds worse than for athletes without any history of these measures. Although the finding is not statistically significant, primarily due to the small sample size, it indicates a potential trend that may be useful for identifying athletes with system deficits by using the combination of subjective factors, history of concussion, and K-D scores. System deficits may result in dysfunctional movement patterns, which over time, could lead to musculoskeletal injuries in competitive play[8, 14)].

The main limitations of the present study included small homogenous sample size, lack of detailed information regarding previous concussions, and a lack of control over extrinsic factors, such as surface type, playing time, and equipment. The pre-season questionnaires should incorporate information regarding the details of previous injuries, including an official diagnosis, date of injury, interventions for injury, and whether full recovery was obtained to improve understanding of an athlete's clinical presentation. Additionally, differences in K-D testing environment may have contributed to variability as the pre-season environment was louder, since athletes had multiple stations, while post-season testing involved less stations with less noise.

The combined use of subjective complaints, history of concussion, and K-D scores during pre-season testing may identify those in need of further assessments for suboptimal neurocognitive processing in order to decrease the risk of sustaining an injury. These measures should be further investigated using a larger sample size with more variety of athletes for population generalization, and utilization of additional assessment tools to better objectify movement pattern deficits.

Funding

This study was not funded.

Conflict of interest

The authors have no conflict of interest to disclose.

REFERENCES

1) Levy ML, Kasasbeh AS, Baird LC, et al.: Concussions in soccer: a current understanding. World Neurosurg, 2012, 78: 535–544. [Medline] [CrossRef]
2) Koutures CG, Gregory AJ, American Academy of Pediatrics. Council on Sports Medicine and Fitness: Injuries in youth soccer. Pediatrics, 2010, 125: 410–414. [Medline] [CrossRef]
3) Covassin T, Moran R, Elbin RJ: Sex differences in reported concussion injury rates and time loss from participation: an update of the National Collegiate Athletic Association Injury Surveillance Program from 2004–2005 through 2008–2009. J Athl Train, 2016, 51: 189–194. [Medline] [CrossRef]
4) Covassin T, Swanik CB, Sachs ML: Sex differences and the incidence of concussions among collegiate athletes. J Athl Train, 2003, 38: 238–244. [Medline]
5) Mollayeva T, El-Khechen-Richandi G, Colantonio A: Sex & gender considerations in concussion research. Concussion, 2018, 3: CNC51. [Medline] [CrossRef]
6) Wunderle K, Hoeger KM, Wasserman E, et al.: Menstrual phase as predictor of outcome after mild traumatic brain injury in women. J Head Trauma Rehabil, 2014, 29: E1–E8. [Medline] [CrossRef]
7) Clark JF, Elgendy-Peerman HT, Divine JG, et al.: Lack of eye discipline during headers in high school girls soccer: a possible mechanism for increased concussion rates. Med Hypotheses, 2017, 100: 10–14. [Medline] [CrossRef]
8) Koenig JP, Puckree T: Injury prevalence, stability and balance among female adolescent soccer players: sport injury. AJPHERD, 2015, 21: 81–91.
9) Gilbert FC, Burdette GT, Joyner AB, et al.: Association between concussion and lower extremity injuries in collegiate athletes. Sports Health, 2016, 8: 561–567. [Medline] [CrossRef]
10) Zemper ED: Two-year prospective study of relative risk of a second cerebral concussion. Am J Phys Med Rehabil, 2003, 82: 653–659. [Medline] [CrossRef]
11) Hides JA, Franettovich Smith MM, Mendis MD, et al.: A prospective investigation of changes in the sensorimotor system following sports concussion. An exploratory study. Musculoskelet Sci Pract, 2017, 29: 7–19. [Medline] [CrossRef]
12) Schneider KJ, Meeuwisse WH, Kang J, et al.: Preseason reports of neck pain, dizziness, and headache as risk factors for concussion in male youth ice hockey players. Clin J Sport Med, 2013, 23: 267–272. [Medline] [CrossRef]
13) Pinto SM, Twichell MF, Henry LC: Predictors of pharmacological intervention in adolescents with protracted symptoms after sports-related concussion. PM R, 2017, 9: 847–855. [Medline] [CrossRef]
14) Swanik CB, Covassin T, Stearne DJ, et al.: The relationship between neurocognitive function and noncontact anterior cruciate ligament injuries. Am J Sports Med, 2007, 35: 943–948. [Medline] [CrossRef]
15) Brooks MA, Peterson K, Biese K, et al.: Concussion increases odds of sustaining a lower extremity musculoskeletal injury after return to play among collegiate athletes. Am J Sports Med, 2016, 44: 742–747. [Medline] [CrossRef]
16) Herman DC, Jones D, Harrison A, et al.: Concussion may increase the risk of subsequent lower extremity musculoskeletal injury in collegiate athletes. Sports Med, 2017, 47: 1003–1010. [Medline] [CrossRef]
17) Benedict PA, Baner NV, Harrold GK, et al.: Gender and age predict outcomes of cognitive, balance and vision testing in a multidisciplinary concussion center. J Neurol Sci, 2015, 353: 111–115. [Medline] [CrossRef]
18) Howitt S, Brommer R, Fowler J, et al.: The utility of the King-Devick test as a sideline assessment tool for sport-related concussions: a narrative review. J Can Chiropr Assoc, 2016, 60: 322–329. [Medline]
19) Leong DF, Balcer LJ, Galetta SL, et al.: The King-Devick test for sideline concussion screening in collegiate football. J Optom, 2015, 8: 131–139. [Medline] [CrossRef]
20) Galetta KM, Morganroth J, Moehringer N, et al.: Adding vision to concussion testing: a prospective study of sideline testing in youth and collegiate athletes. J Neuroophthalmol, 2015, 35: 235–241. [Medline] [CrossRef]
21) Galetta KM, Liu M, Leong DF, et al.: The King-Devick test of rapid number naming for concussion detection: meta-analysis and systematic review of the literature. Concussion, 2015, 1: CNC8. [Medline]
22) Haider MN, Worts PR, Viera KB, et al.: Postexercise slowing on the King-Devick test and longer recovery from sport-related concussion in adolescents: a validation study. J Athl Train, 2020, 55: 482–487. [Medline] [CrossRef]
23) Weise KK, Swanson MW, Penix K, et al.: King-Devick and pre-season visual function in adolescent athletes. Optom Vis Sci, 2017, 94: 89–95. [Medline] [CrossRef]
24) Timpka T, Jacobsson J, Bickenbach J, et al.: What is a sports injury? Sports Med, 2014, 44: 423–428. [Medline] [CrossRef]
25) Gessel LM, Fields SK, Collins CL, et al.: Concussions among United States high school and collegiate athletes. J Athl Train, 2007, 42: 495–503. [Medline]
26) Bernstein JP, Mitchell LS, Bazarian JJ, et al.: The King-Devick test: an indicator of longer-term cognitive effects post-concussion. Acta Neuropsychol, 2015, 13: 229–236.
27) Tsushima WT, Geling O, Arnold M, et al.: Are there subconcussive neuropsychological effects in youth sports? An exploratory study of high- and low-contact sports. Appl Neuropsychol Child, 2016, 5: 149–155. [Medline] [CrossRef]
28) Hwang S, Ma L, Kawata K, et al.: Vestibular dysfunction after subconcussive head impact. J Neurotrauma, 2017, 34: 8–15. [Medline] [CrossRef]
29) Smith AM, Stuart MJ, Roberts WO, et al.: Concussion in ice hockey: current gaps and future directions in an objective diagnosis. Clin J Sport Med, 2017, 27: 503–509. [Medline] [CrossRef]
30) Dhawan P, Starling A, Tapsell L, et al.: King-Devick test identifies symptomatic concussion in real-time and asymptomatic concussion over time. (S11.003). Neurology, 2014, 82: S11.003.