Original Research

Injury prevention strategies at the 2019 FIFA Women's World Cup display a multifactorial approach and highlight subjective wellness measurements

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ABSTRACT

Objective: To report the injury prevention programs utilised by top-level female footballers competing internationally.

Methods: An online survey was administered to physicians of the 24 competing national teams at the 2019 Federation Internationale de Football Association (FIFA) Women's World Cup. The survey included 4 sections regarding perceptions and practices concerning non-contact injuries: (1) risk factors, (2) screening tests and monitoring tools, (3) preventative strategies, and (4) reflection on their World Cup experience.

Results: Following responses from 54% of teams, the most common injuries encountered included muscle strains, ankle sprains, and anterior cruciate ligament ruptures. The study also revealed the most important injury risk factors during the FIFA 2019 World Cup. Intrinsic risk factors include accumulated fatigue, previous injury, and strength endurance. Extrinsic risk factors include reduced recovery time between matches, congested match schedule, and the number of club team matches played. The 5 most used tests for risk factors were flexibility, joint mobility, fitness, balance, and strength. Monitoring tools commonly used were subjective wellness, heart rate, minutes/matches played, and daily medical screening. Specific strategies to limit the risk of an anterior cruciate ligament injury included the FIFA 11+ program and proprioception training.

Conclusion: The present study revealed multifactorial approaches to injury prevention strategies for women's national football teams at the FIFA 2019 World Cup. Challenges to injury prevention program implementation reflect time limitations, schedule uncertainties, and varying club team recommendations.

Level of evidence: IV.
What are the new findings

- There exists a multifactorial approach to injury prevention perceptions and practices among many of the 2019 Federation Internationale de Football Association (FIFA) Women's World Cup team physicians
- Regarding injury risk factors at the 2019 FIFA Women's World Cup, team physicians reported the most important intrinsic risk factors to be accumulated fatigue, previous injury, and strength endurance, and the most important extrinsic risk factors to be reduced recovery time between matches, congested match schedule, and the number of matches played during the club season in the 5 months between January 1st, 2019 and the start of the World Cup on June 7th, 2019.
- Specific strategies to limit the risk of an anterior cruciate ligament injury for players at the 2019 FIFA Women's World Cup included the FIFA 11 + program and proprioception training.
- In addition to objective monitoring tools utilised by team physicians at the 2014 FIFA Men's World Cup, team physicians at the 2019 FIFA Women's World Cup also employed subjective monitoring tools such as wellness that include the elements of sleep, fatigue, stress, and muscle soreness.

1. Introduction

Injury prevention in top-level football is critical to avoid negative outcomes including reduced performance [1,2], financial impact [3], and impaired long-term health of players [4]. Identifying key injury risk factors directly allows for the development of evidence-based prevention strategies. However, little research and uniform recommendations exist with regard to injury prevention for professional female football players.

Three previous studies have begun to establish injury prevention recommendations amongst top-level football players [5–7]. In 2014, McCall et al. surveyed 44 teams across various premier leagues and concluded that their injury prevention programs included: (1) the most important perceived risk factors such as previous injury, fatigue, and muscle imbalance; (2) the most commonly used screening tests such as the functional movement screen, questionnaires, and isokinetic muscle testing; and (3) preventative exercises such as eccentric, specific hamstring eccentric focused, and balance/proprioception exercises [6]. Following this study, McCall et al. conducted a systematic review of the scientific evidence underlying the most important perceptions and practices. They concluded that a majority of these perceptions and practices were not grounded on strong scientific evidence or graded recommendations [7]. Most recently, McCall et al. evaluated injury prevention strategies at the Federation Internationale de Football Association (FIFA) 2014 World Cup. In this study, the authors demonstrated the most important intrinsic risk factors to be previous injury, accumulated fatigue, and agonist: antagonist muscle balance, and the most important extrinsic risk factors to be reduced recovery time, training load prior to and during the World Cup, and congested fixtures [5].

Lower extremity injuries account for 60–80% of all time lost for elite female football players [8], and yet there are limited data on injury risk factors for this population. Thus, whether these previously described injury prevention strategies differ amongst female professional football players competing in FIFA World Cup remains unknown. We aim to determine current practice regarding injury prevention for top-level female footballers competing in the FIFA 2019 World Cup and to investigate the challenges practitioners face while implementing injury prevention programs. We hypothesise that injury prevention programs for top-level female footballers mirror those for top-level male footballers, including injury risk assessment, screening tests, and preventative exercises, and that time limitations are the most significant challenge to program implementation.

2. Methods

National team physicians of the 24 teams competing at the 2019 FIFA Women's World Cup in France were contacted via an email which explained the current study's purpose and provided our survey link. Physicians were asked to submit the survey online. Unanswered questions were excluded from the analysis. The initial email and survey were sent on July 24th, 2019. Surveys were submitted between July 24th, 2019 and December 2nd, 2019. All physicians consented to participate.

In addition to the survey, data regarding match schedules for the 2019 FIFA Women's World Cup, club competitions, international competitions, and international friendslies were obtained via online public resources. These data were used to determine accumulated fatigue prior to the World Cup as well as recovery time between World Cup matches, both of which are commonly cited injury risk factors for the elite male soccer player population [5].

2.1. Survey

The survey was administered in English via online software (Survey Monkey, http://www.surveymonkey.net). The survey contained 4 sections with a total of 32 questions. The 4 sections included: 1) non-contact injury risk factors; 2) assessing non-contact injury risk: testing and monitoring; 3) injury prevention strategies; and 4) personal reflection. Thirty survey questions pertained to team physicians' perspectives on player injury and prevention, 14 of which were open-ended and 16 closed-ended. The questions were modelled from a 2015 McCall et al. article, which evaluated injury prevention strategies at the 2014 FIFA Men's World Cup [5].

2.2. Data analysis

Raw data were exported to Microsoft Excel (Seattle, Washington, USA) for analysis. To evaluate the overall importance of risk factors, points were given based on a system developed for survey research [6]. In this system, each time a physician reported a risk factor as “very important”, it was given 3 points; “important” was given 2 points; “somewhat important” was given 1 point; “not sure” was given 0.5 points; and “not important” was given 0 points. Points were then summed and risk factors were ranked from the highest number of accumulated points to the lowest number of accumulated points, representing a rank of the overall most important to least important risk factor perceived by physicians completing the survey. For open-ended questions that involved the team physician ranking either risk factors for injury or strategies implemented for injury prevention, those ranked first were given 5 points; second, 4 points; third, 3 points; fourth, 2 points; and fifth, 1 point. Open-ended questions were analysed and grouped into an appropriate overall category to allow for an aggregation of the survey results.

Match schedules for the 2019 FIFA Women's World Cup, as well as other international competitions, international friendslies, and club competitions that took place between January 1st, 2019 and the start of the World Cup on June 7th, 2019, were imported into Microsoft Excel (Seattle, Washington). The rest times between the World Cup matches were calculated for both the group and knockout stages. The overall match load for a player leading up to the World Cup was estimated using club and international match schedules.

3. Results

Thirteen (54%) physicians submitted survey responses (team physicians from China, Japan, Korea Republic, Nigeria, United States, Brazil, New Zealand, France, Germany, Italy, Netherlands, Norway, and Spain), with the single physician specifically responsible for team injury prevention strategies requested to complete the survey. Team physicians were not required to complete each portion of the survey. According to team physicians, muscle strains were the most common injury
3.2. Match load leading up to World Cup Finals

Season to be the strongest risk factors for a non-contact injury. Physicians perceived reduced recovery time, a congested match end of halves, as well as a previous injury, proved to be the strongest risk accumulated fatigue from both throughout the season and towards the end of the World Cup. As such, the estimated total player match load ranges from 8 to 22 games in the six months leading up to the 2019 FIFA World Cup.

Table 1

Top 6 most importantly perceived intrinsic and extrinsic non-contact injury risk factors at the 2019 FIFA Women’s World Cup. Note: Risk factors listed are those perceived by team physicians and not objectively or statistically confirmed.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Intrinsic Risk Factor</th>
<th>Accumulated points of importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>Accumulated fatigue (i.e., throughout a season/congested match periods)</td>
<td>33</td>
</tr>
<tr>
<td>2nd</td>
<td>Accumulated fatigue (i.e., towards the end of halves)</td>
<td>30</td>
</tr>
<tr>
<td>3rd</td>
<td>Previous injury</td>
<td>29</td>
</tr>
<tr>
<td>3rd</td>
<td>Strength endurance (i.e., resistance to fatigue)</td>
<td>29</td>
</tr>
<tr>
<td>4th</td>
<td>Muscle imbalance (Agonist-Antagonist)</td>
<td>28</td>
</tr>
<tr>
<td>4th</td>
<td>Acute fatigue (i.e., following intense actions in a match)</td>
<td>28</td>
</tr>
</tbody>
</table>

FIFA, Federation Internationale de Football Association

3.3. Recovery time between matches during the World Cup Finals 2019

Mean recovery time between 2019 FIFA World Cup matches varied by the tournament stage: group stage recovery time was 4.7 days (range: 3.75–5.25 days); recovery time prior to the round of 16 was 5.1 days (range: 3–8 days); recovery time prior to quarter finals was 4.4 days (range: 3.8–5 days); recovery time prior to semi-finals was 4.3 days (range: 4–5 days); and recovery time prior to finals was 4.3 days (range: 3.8–4.6 days).

3.4. Assessment and monitoring of injury risk

Seven of 12 responding teams confirmed an assessment of players’ individual injury risk profiles. Joint mobility, joint flexibility, and physical fitness were the most cited screening tests implemented by team physicians to identify players’ non-contact injury risks (Fig. 2). During the World Cup, specifically, team physicians most commonly employed subjective wellness (sleep, fatigue, stress, and muscle soreness), heart rate, the number and/or minutes of matches played, and daily medical screening to monitor non-contact injury risk during this period (Fig. 3).

3.5. Injury prevention strategies

Eight of 10 responding teams implemented injury prevention strategies for the World Cup. All of these 8 teams implemented their injury prevention strategies during both the World Cup training camps and tournament. Three of the 8 teams customised these programs based on individual players’ injury risks. While teams did not specify reasoning for a lack of injury prevention program implementation, studies show that challenging factors include time limitations, identifying a leader to consistently facilitate prevention program sessions, team support of programs, complexity of programs, and match/practice schedule changes [9]. Additionally, a subset of players work with their club teams for a significant portion of the year, which may pose challenges to the implementation of prevention programs at the national team level.

Injuries in exercise programming variables between training camps and the World Cup tournament. During the World Cup tournament, team physicians reported the following exercise program adjustments for players: reduced load (8 teams, 100%), reduced frequency (4 teams, 50%), changes in exercise type (4 teams, 50%), and reduced sets and repetitions (2 teams, 25%).

Six of 10 responding teams implemented preventative strategies aimed at player psychology. Of the psychological stressors, stress was most commonly targeted by preventative strategies (5 teams), followed by anxiety (4 teams), motivation (3 teams), and depression (2 teams). No teams targeted coping (0 teams) as a psychological stressor.

3.6. Strategies used to limit risk of ACL injury

Strategies used by teams to mitigate the risk of an ACL injury varied. Only two strategies were cited by more than one team: the FIFA 11+ program and proprioception training. FIFA 11+ is a complete warm up program which focuses on core strength, leg strength, balance, and agility to reduce injury risk for soccer players.

Additionally, one team each described reducing knee valgus while landing, strengthening of hip muscles, strengthening of knee stabilisers, and core strengthening as strategies to limit the risk of an ACL injury.
3.7. Efficacy of and challenges to preventative strategies

Ten team physicians commented on the efficacy of their injury prevention practices. Two physicians felt that the team’s strategies were successful at reducing non-contact injuries and that they could not have done a better job. Five team physicians stated that the team’s strategies were successful in reducing non-contact injuries, however, they could have been better. Three team physicians were unsure of the impact that their injury prevention strategies made. Challenges frequently cited in implementing successful strategies to reduce non-contact injury risks included a tight match schedule, limited rest time between matches, and uncertainty of schedules. Additionally, players on the same national team but varying club teams received different injury prevention instructions from their club teams (specific club team injury prevention strategies were not discussed in this study). This presented challenges in implementing unified injury prevention strategies.

Lastly, of twelve responding team physicians, six felt that compliance is “essential” in reducing and controlling non-contact injuries, while the remaining six felt it is “very important.”

4. Discussion

The primary goals of our study were to investigate perceptions and practices of 2019 FIFA Women’s World Cup national team physicians regarding risk factors, screenings tests, and preventative strategies for non-contact injuries and to analyse challenges encountered during injury prevention. This study revealed the most common injuries amongst elite female football players during the 2019 FIFA World Cup to be muscle strains, ankle sprains, and ACL ruptures. Additionally, the study highlighted the most important intrinsic risk factors (accumulated fatigue, previous injury, and strength endurance) and extrinsic risk factors (reduced recovery time between matches, a congested match schedule, and the number of matches played during club season) during the 2019 FIFA World Cup. The 5 most used tests to evaluate risk factors were flexibility, joint mobility, fitness, balance, and strength. Monitoring tools commonly used were subjective wellness, the heart rate, minutes/matches played, and daily medical screening. Specific strategies to limit the risk of an ACL injury included the FIFA 11+ program and proprioception training (Fig. 4). Reported challenges to implementing injury

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**Fig. 1.** International matches leading up to the 2019 FIFA Women’s World Cup. FIFA, Federation Internationale de Football Association.

**Fig. 2.** Most common non-contact injury risk screening tests used by national teams at the 2019 FIFA Women’s World Cup. FIFA, Federation Internationale de Football Association.
prevention programs centred around tight, uncertain match schedules and management of varying recommendations provided to players by their club teams.

Several key differences were found while comparing the results of our study’s 2019 FIFA Women’s World Cup injury prevention practices with the 2014 FIFA Men’s World Cup injury prevention practices examined by McCall et al. [5]. Firstly, regarding the most important intrinsic risk factors, both studies concluded previous injury and accumulated fatigue as critical variables. While physicians’ of both the men’s and women’s national teams ranked reduced recovery time as a key extrinsic risk factor, men’s team physicians noted training load prior to and during the World Cup and congested fixtures to be other important risk factors. Disparately, female teams’ physicians cited congested match schedules and the number of club season matches played as more critical variables. Fig. 1 and Table 2 are illustrative of the match schedules referenced by 2019 FIFA Women’s World Cup team physicians. The most used tests to assess risk factors were nearly identical but monitoring tools demonstrated unique differences. Specifically, the physicians of the men’s teams focused on objective variables such as medical screening, minutes played, heart rate, and biochemical markers, while the physicians of the women’s teams ranked subjective wellness as the top monitoring tool while also introducing other more subjective tools such as the rating of perceived exertion. Of note, McCall et al. did not evaluate most common injuries in the FIFA 2014 Men’s World Cup. As such, this information is not available for direct comparison.

The literature regarding gender-specific injury patterns remains mixed: some studies demonstrate similar overall injury rates between men and women [10,11], others conclude a higher injury incidence amongst male versus female soccer players [12,13], and some suggest a higher injury incidence amongst female versus male soccer players [14, 15]. Female athletes have been reported to suffer more injuries to the hip [16,17], lower leg, and shoulder than male athletes, while males suffer more thigh injuries [16]. Specifically in football, knee injuries are more prevalent amongst female than male players [18]. Ristolainen et al. used a survey to evaluate differences in sport-related injuries between elite male and female athletes in four different sports, including football [19]. The authors concluded no gender differences in acute or overuse injuries per 100 exposure hours. However, some gender differences were observed in anatomical injury locations. Namely, there was a greater number of overuse injuries in the posterior thigh in male versus female athletes, whereas females had a greater risk for overuse injuries to the ankle. Additionally, a higher proportion of female soccer players had more combined acute and overuse injuries in the ankle and knee than male players. This may be contributed in part by higher joint laxity in females [20]. This discrepancy in injury rates between male and female soccer players warrants investigation of differences regarding injury prevention practices utilised for the two groups.

While the literature does not reveal a consensus regarding the overall injury incidence in male versus female soccer players, data do report that women suffer more knee injuries than men, especially ACL injuries with a four to six times increased risk of an ACL injury compared with male athletes [18,21–23]. Additionally, a study by Brophy et al. followed football players for 7 years after ACL reconstruction and concluded that females were more likely than males to require additional surgery and were less likely to return to play [24]. However, prevention programs to reduce the rate of ACL injuries, such as the FIFA 11+, have demonstrated an injury reduction of 50%–70% [25]. As such, this study reports the use of FIFA 11+ along with additional ACL injury prevention programs at the 2019 FIFA Women’s World Cup.

Numerous ACL injury prevention programs have proven successful in reducing the rate of injury [26]. Specifically, neuromuscular and proprioceptive preseason protocols were designed to train female athletes to

Fig. 3. Most commonly used monitoring tools for national teams at the 2019 FIFA Women’s World Cup. FIFA, Federation Internationale de Football Association.

Fig. 4. Key components of injury prevention strategies per 2019 FIFA Women’s World Cup team physicians. FIFA, Federation Internationale de Football Association.
avoid placing their knees in at-risk positions while landing or in cutting manoeuvres [27]. In a systematic review, Ramirez et al. demonstrated the risk of an ACL rupture to be 1.83 times higher for female athletes who did not participate in neuromuscular ACL injury prevention programs [23]. A study by Brophy et al. evaluated non-contact ACL injuries in soccer players by gender and demonstrated female athletes as more likely to experience ACL injury in their supporting leg, whereas males tend to injure their kicking leg. This difference may in part highlight an anatomical variation between the female and male athletes including a more narrow femoral notch width and increased knee hypermobility in females. A proposed mechanism for this disparity in ACL injury dexterity includes increased valgus in the supporting leg of female compared to male athletes when landing from a jump, which may be explained by differences in the hip abductor and extensor strength, hip and knee flexion, core control, and hamstring activation [27]. To improve ACL injury prevention programs, further investigation of modifiable risk factors which may lead to increased rates of supporting leg ACL injury amongst female soccer players is needed.

In addition to physical stressors, psychological stressors also play an important role in injury risk. Accordingly, implementing strategies to minimise psychological stressors are noted by both national team physicians in this study and in the literature. High levels of personal and athletics-related stress are shown to increase injury risk, perhaps related to the alteration of attention and coordination and increase in muscle tension [28]. Some studies support the idea that adding psychological components (setting goals, mindfulness, cognitive-behavioural biofeedback, etc.) to injury prevention programs decreases the risk for injury and improves the recovery trajectory [29].

Lastly, Physical Analysis of the FIFA Women's World Cup France 2019™ demonstrated an increase in game demands from the 2015 Canada competition to the 2019 France competition. While this highlights the importance of developing systematic training programs to better prepare players for competition, there remains an overall lack of scientific literature on female athletes. This paper aims to expand literature regarding female athlete injury prevention strategies as well as injury types.

The limitations of this study include the use of self-reported, although validated, questionnaires. Additionally, the data were retrospective in nature, collected solely via email, had a 54% survey completion rate, and is thus susceptible to both selection and reporting bias.

5. Conclusion

The present study reveals a multifactorial approach to injury prevention practices at the 2019 FIFA Women's World Cup. Included in this approach are assessments of intrinsic and extrinsic injury risk factors, physical testing, objective monitoring (heart rate, daily medical screening, and playing time), and ACL injury prevention programs (Fig. 4). In contrast to team physicians at the 2014 FIFA Men's World Cup, 2019 Women's World Cup physicians also included subjective monitoring of sleep, fatigue, stress, and muscle soreness as a part of injury prevention strategies. Challenges cited by team physicians regarding injury prevention program implementation include tight match schedules, schedule uncertainties, and unifying injury prevention guidelines amidst variable club team recommendations.

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Conflicts of interest

Eliana B. Saltzman, MD: none.
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Cymedica: stock or stock Options.
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Gramercy Extremity Orthopaedics: stock or stock Options.
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Appendix A. Supplementary data

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References
