

Impact of ankle taping on dynamic balance and functional performance following fatigue simulation in elite youth soccer players with chronic ankle instability

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Abstract

Numerous activation energy systems, encompassing both aerobic and anaerobic pathways, are essential to fulfill the energy requirements of muscles during a 90-min soccer match. In the later phases of the game, a decline in physical performance becomes evident, marked by reduced work rate, muscular force output, and efficacy in high-intensity activities. Progressive fatigue sets in, prominently impacting dynamic balance and overall functional performance among players. A previous study highlighted a noteworthy 48% occurrence of ankle sprain injuries during the latter part of a soccer match, particularly within the last 15 min of each half; this issue is especially prevalent among elite youth soccer players. Motivated by this, our study aimed to evaluate the impact of ankle taping on dynamic balance and functional performance after fatigue induced in elite youth soccer players dealing with chronic ankle instability. Employing a pre- and post-quasi-experimental study design, participants were selected from a football academy, focusing on elite youth soccer players with chronic ankle instability. The study groups comprised an intervention group subjected to ankle taping and a control group without taping. Dynamic balance was assessed using the Y balance test (YBT), and functional performance was quantified through the single-leg hop test (SLHT) following a fatigue-inducing protocol. The results unveiled a significant time × group interaction in SLHT for functional performance ($p < 0.0125$), indicating a significant impact of ankle taping. Conversely, no significant interaction was observed for dynamic balance across all directions (anterior [ANT], posteromedial [PM], and posterolateral [PL]). However, a noteworthy between-group change was evident in PM, PL, and SLHT for POST5, POST20, and POST35 ($p < 0.0125$). Our findings strongly suggest that ankle taping, particularly with rigid tape, exerts a significant positive effect on preserving ankle stability and lower limb function against the deleterious effects of fatigue in elite youth soccer players coping with chronic ankle instability.

Keywords: Ankle taping, Ankle sprain, Balance, Single leg hop test, Soccer, Y balance test.

Introduction

Soccer, a sport celebrated for its dynamic nature and agility, is not without its physical toll. In the spectrum of soccer-related injuries, ankle sprains, particularly inversion sprains, have become the most common musculoskeletal affliction, accounting for a significant 20% of all soccer-related injuries (Gribble et al., 2016; Gulbrandsen et al., 2019; Owosye et al., 2020). The incidence of ankle sprains in soccer is notably pronounced, with reports indicating a range between 0.79 to 3.21 sprains per 1,000 athlete exposures. Of particular concern is the disproportionately high susceptibility experienced by elite youth soccer players, who face a risk that is 2.3 to 4.9 times higher than their professional counterparts (Pfirrmann et al., 2016). The ramifications of ankle sprains extend beyond the immediate injury, often culminating in the vexing and persistent condition known as Chronic Ankle Instability (CAI).

Chronic ankle instability, characterised by an enigmatic and persistent course, presents a constellation of distressing symptoms. These include pain, localised swelling, decreased joint stability, muscular weakness, compromised postural control, and impaired balance (Arnold et al., 2009; Gribble et al., 2014). However, the most disquieting facet of CAI is the persistent risk it imposes for recurrent ankle injuries, with individuals afflicted by this condition facing an alarming 70% probability of reinjury (Doherty et al., 2017).

In the sphere of soccer, where the outcome of a match can be determined by a single moment of brilliance or misfortune, the final stages of a game are fraught with the looming spectre of injury. The study conducted by Hamdan et al. (2022) revealed that among elite league athletes in Malaysia, the most perceived risk factors for injury were fatigue and muscle dysfunction, with a high prevalence of 91.1%, followed by coordination, physical condition, and a prior history of injury were also identified as significant contributing factors. A systematic review and meta-analysis conducted by López-Valenciano et al. (2020) also mentions the prominence of injuries occurring in the latter stages of soccer matches and identified fatigue as a significant contributor to ankle vulnerability. Soccer-specific fatigue has been highlighted as a pronounced risk factor for ankle injuries, supported by a growing body of evidence that illustrates its deleterious impact on the sense of position of the ankle joint, balance, and reactive postural control (Greig & McNaughton, 2014; Mohammadi & Roozdar, 2010; Pau et al., 2014).

Furthermore, research has elucidated the scope of the fatigue-induced decline, which encompasses reductions in work rates (Chmura et al., 2018), muscular force output (Maly et al., 2018), and overall athletic performance (Ramos et al., 2017) during the latter stages of soccer matches. These cumulative findings shed light on the impact of fatigue on the muscles crucial for ankle stabilisation, with a particular focus on the peroneal muscles, which are susceptible to diminished activation, potentially explaining the increased susceptibility to ankle sprains (Doherty et al., 2014). In particular, a history of ankle sprain, an inherently unstable ankle joint, and the presence of functional instability have been identified as contributing factors that increase the risk of ankle sprains inversion (Thompson-Kolesar et al., 2018).

In response to the demands of ankle injury prevention and instability management, the application of ankle taping has become a prevalent strategy in the world of sports. A systematic review and meta-analysis by Rowe et al. (2022) mentioned individuals suffering from CAI frequently employ external ankle supports like taping and bracing to enhance stability and minimize the likelihood of experiencing recurrent sprains. It is postulated to confer external mechanical support and enhance postural control (Kaminski et al., 2019). However, despite its widespread adoption, uncertainties continue to linger regarding its efficacy, especially in the context of dynamic functional performance, the prevention of ankle injuries, and the amelioration of fatigue's detrimental effects among elite youth soccer players.

Moreover, the application of rigid ankle taping to counteract the negative impact of fatigue during matches remains a subject of ongoing debate. Consequently, the principal objective of this study is to undertake a comprehensive investigation into the influence of ankle taping on dynamic balance and functional performance in elite youth soccer players experiencing states of fatigue, all within the context of chronic ankle instability. This research aspires to illuminate the intricate interplay between ankle taping, fatigue, and athletic performance, thus offering valuable insights for the development of evidence-based injury prevention and management strategies tailored to the unique needs of elite youth soccer players.

Methods

Participants

A group of elite youth soccer players from a national soccer academy was enrolled in this study. The participants were included if they had participated in the Youth National League under 18 and 21, were regular trained 3 to 5 times per week with a duration of 40 to 60 minutes per session, had a history of at least one significant ankle sprain, with the first sprain that occurred at least last 12 months prior to the study, had Cumberland Ankle Instability Tool (CAIT) score less than 24 and were able to run and jump without pain. The participants were excluded from the study if they had history of lower extremity or low back pain, had suffered with cardiovascular disease or any systemic conditions that limits the physical activity, and were ergogenic aid users. In addition, their participation in this study were declined if they had acute injury to any other lower limb joints that interrupted desired physical activities for at least one day.

All participants signed and informed consent form approved by the institutional ethic committee before their participations. Permission to employ the study among the soccer players was granted from the respective football academy. Participants were explained the procedures and were informed that they could withdraw from the study at any time without penalty or any loss of benefits.

Design

A pre-and-post-quasi-experimental study design with two groups of elite youth soccer players was used to examine the effect of ankle taping on dynamic balance and functional performance after induced fatigue. The participants were allocated into two groups; the intervention group received an ankle rigid taping prior to the warm-up, while the control group had no received ankle taping. The fatigue was induced through a specific approach known as 'The Youth Soccer Fatigue Simulation (YoSFS⁵)' outlined by Bukry et al. (2022) YoSFS⁵ required participants to complete 5 minutes of circuit involving several soccer-specific movements (kicking, jumping, and heading, sprints with a ball) (Fig. 1).

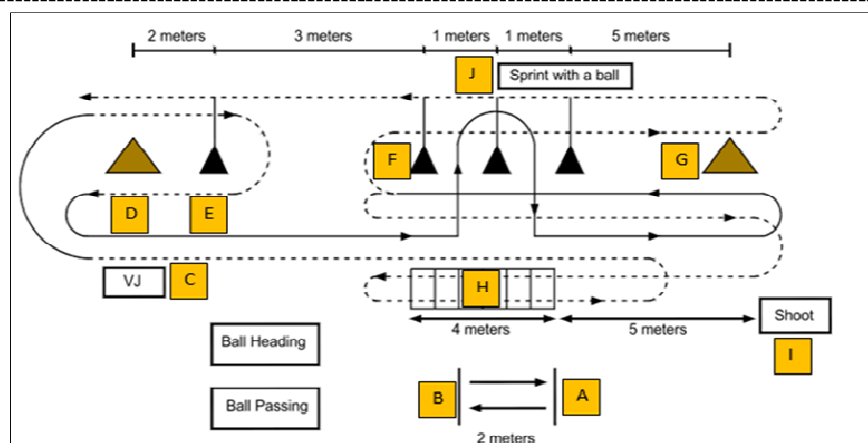


Fig. 1. The YoSFS⁵ fatigue protocol design

Procedures

Initially, participants in both groups were familiarized with the protocol (Fig. 1 and Table 1) before the actual testing. The familiarization session was conducted with two methods, the first one by physically familiarization, and secondly the participant was given the video recorded of the procedure of the testing for their references. During the familiarization sessions, participants were allowed to practice until they were able to perform the tests with confidence. The familiarization session was monitored by a researcher to ensure the tests were carried out accurately by the participants.

During the sessions, participants in the intervention group had received a nonelastic sports tape to the affected ankle (Leuko SportsTape, Beiersdorf Australia Ltd, North Ryde) without application of an under wrap. To ensure the consistency of the taping technique, the application of taping on the participants was always performed by the same therapist who was trained accordingly. The taping technique that was used in this study was taken from studied by Halim-Kertanegara et al. (2017), the method used an anchor, two stirrups, 3 figure of six which two of them for preventing inversion, and one for preventing eversion, heel lock, and lock-off (Fig. 2). As for participants in the control group, they did not receive any forms of sports tape.

All participants were instructed to perform PRE-TEST after 30 minutes of FIFA 11+ warm-up program, which included running, strengthening, plyometric and balance component. Heart rate (HR), Rating of Perceived Exertion (RPE), Countermovement Jump (CMJ), Y-Balance test (YBT) and Single leg hop test (SLHT) were recorded in the session. After that, they were required to perform the YoSFS⁵ for 5 minutes. Figure 3 illustrates the time data recording for real test. The YoSFS⁵ fatigue protocol involves high intensity activities; the activity sequences (Table 1) are instructed using verbal cues on an audio recording. All measurements were recorded before the test (PRE-TEST), a test immediately following YoSFS⁵ (POST5), after 15 min of passive rest (POST20) and after 30 min of passive rest (POST35). These moments in time were selected to define the prolonged effect of YoSFS⁵. All measurements were recorded by a well-trained research assistant.

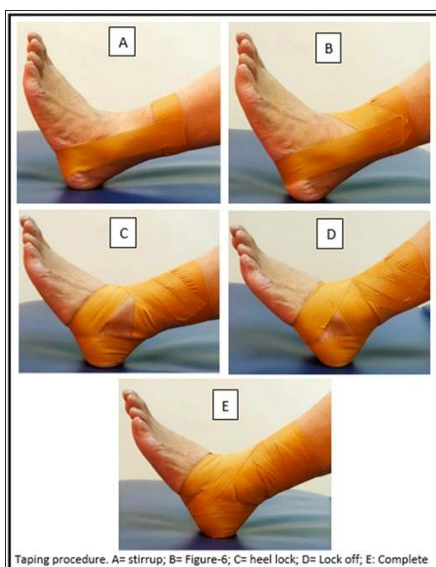
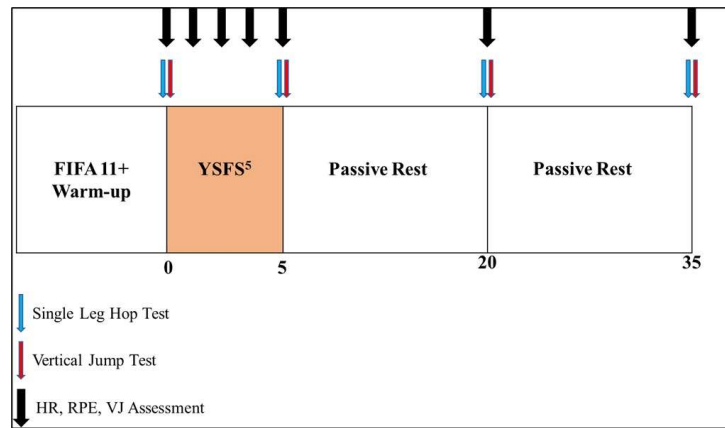


Fig. 2. The taping procedure for intervention group



Abbreviation; HR: heart rate; VJ: vertical jump; RPE: Rate of Perceived exertion

Fig. 3. The illustration of the time data recording for real test

Table 1: Activity profile of YoSFS⁵.

No.	YoSFS ⁵	Time (s)
0	5x Ball Passing	
1	Stand	4
2	Up Jog	10
3	5x Ball double leg jump heading	17
4	Side Stride	7
5	Agility ladder drill + 1 x Ball shooting	17
6	VJ + up Jog	10
7	Sprint with a ball	6
8	Stand	4
9	Up Jog	10
10	5x Ball Passing	17
11	VJ + up Jog	10
12	5x Ball double leg jump heading	17
13	Side Stride	7
14	Agility ladder drill + 1 x Ball shooting	17
15	Stand	4
16	Up Jog	10
17	5x Ball Passing	17
18	VJ + up Jog	10
19	Jog	10
20	Up Jog	10
21	5x Ball double leg jump heading	17
22	VJ + Up Jog	10
23	Agility ladder drill + 1 x Ball shooting	17
24	Side Stride	7
25	Stand	4
26	5x Ball Passing	17
27	Up jog	10
28	Sprint with a ball	6
29	VJ	

Abbreviation; VJ: Vertical jump

Measurements

This study measured dynamic balance using YBT and functional performance using a single leg hop test. The YBT was instructed with participant stood on the center of the modified Star Excursion Balance Test (SEBT) grid in the single leg stand position with shoes on. Then, participants were told to perform maximal reaches with the non-stance limb in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions (Fig 4.A) while maintaining a single-leg stance on the affected leg.

Participants were instructed to perform 9 repetitions for each direction, with 6 times practices and measurements were recorded at 7th, 8th and 9th. The average distance (adjusted reach) of three trials of the Y balance test is calculated using the following formulas and standardized to the length of its limbs (relative reach):

$$\text{Relative Reach Distance: } \frac{\text{Absolute reach distance (cm)}}{\text{Leg Length (cm)}} \times 100$$

Apart from that, for the procedure of SLHT was followed by Rosen et al. (2019) participants were required to hop laterally (10 repetitions) over a 30 cm distance and back in a single-leg stance on the affected leg, as quickly as possible (Figure 4.B). The time were recorded to measure how fast the participants complete the task.

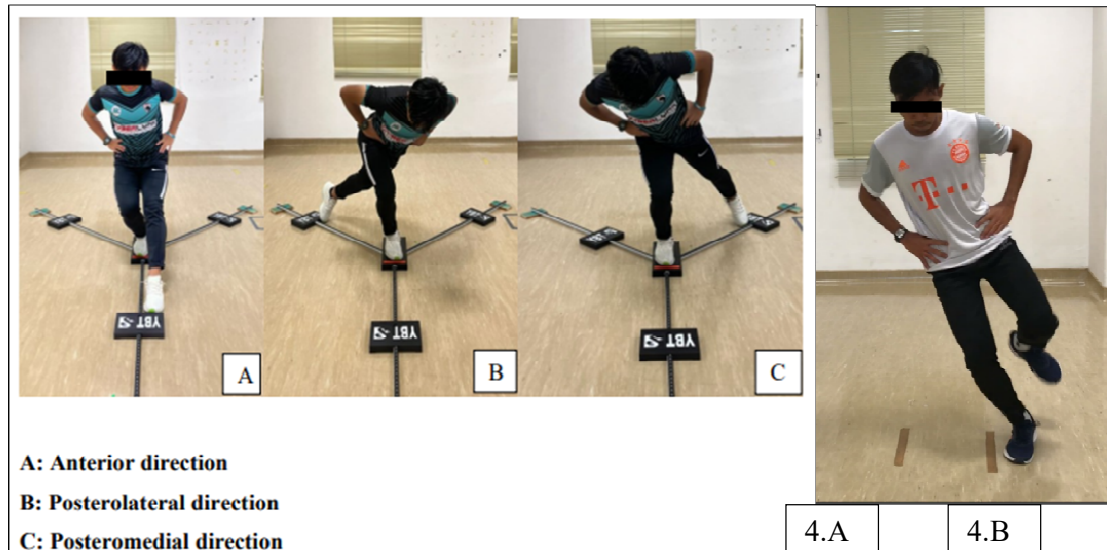


Fig. 4. Outcome Measure for dynamic balance and functional performance. (4.A) The Y-Balance test; (4.B) The single leg hop test

Statistical analyses

To assess the effect of ankle taping on dynamic balance and functional performance after fatigue was induced among elite youth soccer players with chronic ankle instability, a two-by-four mixed repeated-measures analysis of variance (ANOVA) as the within-between dependent variables comparisons was performed. Bonferroni procedures was used for post-hoc analysis, and the alpha level was set at $p < 0.0125$. All results are presented as mean $\pm$ SD. Where the sphericity assumption was violated, the Greenhouse-Geisser correction was used. Effect size was evaluated where $d < 0.2$ constitutes a small effect, $0.2 \leq d < 0.5$ a medium effect, and $d \geq 0.8$ a large effect. (Cohen, 1988) All data was entered and coded into a personal computer using a Statistical Package for Social Sciences (SPSS) Version 28 (SPSS Inc., USA).

Results

Twenty-eight ($n=28$) elite youth soccer players with chronic ankle instability were enrolled and completed the study. The mean age of participants was 18.65 years (± 1.10). Other clinical characteristics of the participants include mean height of 166.54 cm (± 5.57), mean weight of 56.54 kg (± 6.00), mean BMI of 20.35 kg/m² (± 1.45), and mean limb length of 90.14 cm (± 4.23) (Table 2).

Table 2: Descriptive analysis.

Characteristics	Control N:14 Mean $\pm$ SD	Intervention N:14 Mean $\pm$ SD	Significant (p value)
Age (years)	19 $\pm$ 1.301	18.93 $\pm$ 0.829	0.864
Limb length (cm)	89.32 $\pm$ 3.079	90.96 $\pm$ 5.387	0.331
Weight (kg)	55.71 $\pm$ 5.967	57.36 $\pm$ 6.033	0.475
Height (cm)	165.43 $\pm$ 4.052	167.64 $\pm$ 7.089	0.322
BMI (kg/m ²)	20.34 $\pm$ 1.781	20.36 $\pm$ 1.114	0.970

A two-by-four mixed analysis of variance between subjects (ANOVA) revealed a significant interaction of group-by-time effect ($F(3,78) = 8.32$, $p < 0.001$, $d = 0.242$) in SLHT for functional performance after induced fatigue. However, no significant interaction was found in all dynamic balance directions (ANT, PM, and PL). The results were summarized in Table 3. Between group differences showed that significant effect in PM ($F(1,26) = 8.29$, $p = 0.008$, the $d = 0.242$) and PL ($F(1,26) = 8.50$, $p = 0.007$, $d = 0.246$) for dynamic balance and SLHT ($F(1,26) = 13.45$, $p = 0.001$, $d = 0.341$), but no significant in ANT of dynamic balance.

Post-hoc comparisons using the Bonferroni test indicated that the significant level between group of dynamic balance (PM and PL) for POST5, POST20 and POST35 with the p value < 0.0125 (Fig. 5A, B, C). However, the PRE level of the group interaction in PM and PL direction showed an insignificant effect with a p

value of 0.024 and 0.020 respectively. Meanwhile, post hoc comparisons between groups of SLHT for PRE, POST5, POST20, and POST35 showed significant with p value = 0.0125 (Fig. 5D).

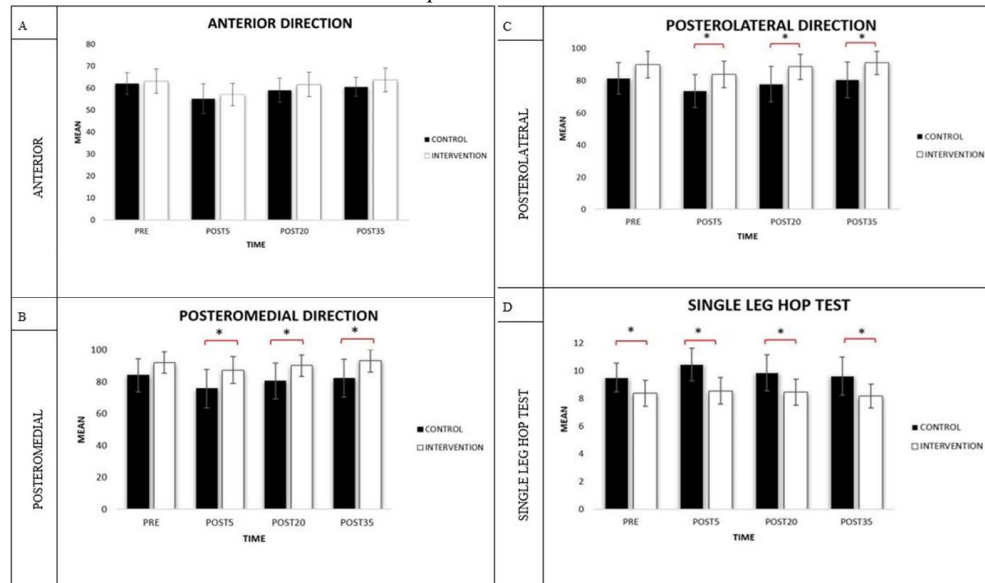
Between-time interaction within group revealed a significant difference in ANT, PM, PL and SLHT ($p < 0.0125$). The confidence level of ANT direction after induced fatigue POST5 (mean difference, 56.19; 95% confidence interval [CI]: 54, 58.4; POST20 (mean difference, 60.41; 95% CI: 58.3, 62.5) and POST35 (mean difference, 62.22; 95% CI: 60.4, 64) were significantly higher than PRE-fatigue (mean difference, 62.68; 95% CI: 60.7, 64.6). POST5 mean difference 81.41; 95% CI: 77.6 to 85.2; POST20 (mean difference, 85.17; 95% CI: 81.8, 88.5) and POST35 (mean difference, 87.62; 95% CI: 84.1, 91.1) of PM direction were significantly greater than before fatigue PRE (mean difference, 87.99; 95% CI: 84.8, 91.2).

The confidence level of PL direction after induced fatigue POST5 mean difference 78.57; 95% CI: 75.1 to 82; POST20 (mean difference, 83.09; 95% CI: 79.6, 86.6) and POST35 (mean difference, 85.6; 95% CI: 82.2, 89) were significantly larger than before fatigue PRE (mean difference, 85.57; 95% CI: 82.2, 88.9). There was also significant higher of SLHT in POST5 (mean difference, 9.49; 95% CI: 9.09, 9.89), POST20 (mean difference, 9.15; 95% CI: 8.73, 9.57) and POST35 (mean difference, 8.89; 95% CI: 8.49, 9.3) compared to PRE-fatigue (mean difference, 8.93; 95% CI: 8.56, 9.3).

Table 3: Mean, standard deviation and significant effect for dynamic balance and functional performance.

Variable	Group	Mean ± SD				Mixed-ANOVA Interaction (Group x Time)	Group (G)	Time (T)				
		PRE	POST 5	POST 20	POST 35							
Dynamic Balance Anterior	Control	62.18 ± 4.93	55.27 ± 6.81	59.08 ± 5.59	60.63 ± 4.29	0.163	0.280	<0.001*				
		Intervention	63.19 ± 5.56	57.11 ± 5.17	61.73 ± 5.51				63.81 ± 5.36			
	Control		81.33 ± 9.89	73.41 ± 10.32	77.78 ± 10.88				80.36 ± 11.15	0.399	0.007*	<0.001*
		Intervention	89.81 ± 8.18	83.72 ± 8.38	88.39 ± 7.87				90.83 ± 7.20			
Posteromedial	Control		84.02 ± 10.43	75.58 ± 12.03	80.31 ± 11.25	82.19 ± 11.94	0.154	0.008*	<0.001*			
		Intervention	91.96 ± 6.76	87.24 ± 8.44	90.03 ± 6.81	93.04 ± 7.07						
	Functional Performance		Control	9.50 ± 1.04	10.44 ± 1.18	9.84 ± 1.31				9.61 ± 1.37	<0.001*	0.001*
		Intervention		8.36 ± 0.93	8.53 ± 0.96	8.45 ± 0.94				8.17 ± 0.85		

*The p value is at 0.0125 level



* p value < 0.0125 compare with control group

Fig. 5. The effects between group of rigid taping and control group on the Anterior (A), Posterolateral (B), Posteromedial (C) direction of the Y-Balance test and Single leg hop test (D) after fatigue simulation among youth soccer players with chronic ankle instability during PRE, POST5, POST20, and POST35.

Discussion

This study aimed to investigate the effect of ankle support on dynamic balance and functional performance after YoSFS⁵ protocol among elite youth soccer players with chronic ankle instability. The findings of this study showed a difference between the rigid taping group and control groups during POST5, POST20, and POST35, on functional performance and dynamic balance, particularly in the PL and PM directions after simulated fatigue. The rigid tape group revealed that the application of rigid tape positively affected the functional performance and dynamic balance compared to the control group.

These results are consistent with the previous studies in which a significant effect of rigid tape on preserving the dynamic balance was found when compared to the control group (Hadadi et al., 2020; Laddawong et al., 2019; Mikyoung et al., 2020; Mohamed et al., 2016). The effect was proposed due to compensation of rigid tape for the reduced feedback of damaged proprioceptors (Hadadi et al., 2020; Jackson et al., 2016; Mikyoung et al., 2020); activating sensory receptors in the epidermis (Mikyoung et al., 2020); and enhances the afferent feedback (Jackson et al., 2016).

The taping technique was adapted from Halim-Kertanegara et al. (2017) which focuses on the medial and lateral parts of the ankle joint. The completed closed wrap taping method's eight-like shape and heel-lock structure were expected to improve the ankle's degree of stability (Yalfani & Raeisi, 2021). Similarly, the results of this study demonstrate better preservation in PL and PM dynamic balance but not for the ANT direction. In contrast, previous research found that rigid tape did not improve dynamic balance (Bicici et al., 2012; Bieringer, 2011; Gehrke et al., 2018; Jelinek et al., 2019; Kodesh & Dar, 2015). The inconsistency of the results could be due to the variance of application technique of the rigid tape and the variation of the coverage of the ankle joint area. Studies done by Gehrke et al. (2018) and Someeh et al. (2015) attempted to use tapes for repositioning, while the study by Halim-Kertanegara et al. (2017) used an application that appeared to serve a greater mechanical restriction function.

Previous research showed that fatiguing protocols such as isolated muscle fatigue (Gribble et al., 2009; Gribble & Hertel, 2004) lower limb fatiguing exercises (Gribble et al., 2009; Johnston et al., 2018), treadmill running (Wright et al., 2013), and high-intensity intermittent exercise (Whyte et al., 2015), significantly influenced dynamic postural control. This study present similar findings as these previous studies, it indicates that YoSFS⁵ protocol can serve as a non-harmful, reversible fatigue-inducing intervention. Therefore, this protocol maybe useful for future studies on soccer athletes in fatigue status. A study by Johnston et al. (2018), showed that the recovery period from the negative effects of fatigue was nearly 20 to 30 minutes. Current study also showed similar results in which all the parameters at POST35 after induced fatigue resumed to PRE level. Furthermore, data of elite youth soccer players with rigid taping in this study apparently demonstrates a shorter recovery period from induced fatigue.

Moreover, the rigid taping group recovered faster compared to the control group during SLHT. The result can be seen after fatigue recovery at POST20 and POST35, which were both near the baseline-PRE readings in present study. The recovery effect at PRE-POST20 revealed that the rigid tape group took the least amount of time to recover, with a value of 1.07%, compared to 3.89% for the control group. Subsequently, the effect on PRE-POST35 showed that the rigid tape group was -0.59% higher than the baseline, while the control group was 1.26%. Previous studies found that soccer players typically need 48 to 72 hours to recover from metabolic homeostasis, muscle trauma, and anaerobic performance decrements caused by fatigue during real matches (Edelec et al., 2014; Russell et al., 2015).

Apart from that, there was a significant improvement of rigid taping in functional performance measured by the single-leg hop test. The results are aligned with a recent study done by Halim-Kertanegara et al. (2017), who found that the rigid taping application did not harm athletes' performance with chronic ankle instability and enhances athletes' perceptions of confidence, security, and safety while performing performance task. Similarly, earlier study conducted by Someeh et al. (2015) showed that athletes with CAI had a reduction in performance in all functional performance activities; however, the use of rigid tape in the study noted a significant enhancement in their performance compared to those without tape. The application of rigid taping as the external support in the study improved the skin proprioceptive receptors, which provide additional awareness of foot position and direction of motion.

Rigid tape was found to be more effective with a slight loss of restrictive properties when applied 30 minutes prior to the exercise (Purcell et al., 2009). In this present study, the application of rigid tape among elite soccer players with chronic ankle instability was carried out before the FIFA 11 + warm-up session which took 30 minutes to complete, and the PRE-test was recorded immediately after the warm-up session. The effect of rigid tape also found to provide an instant effect and prominent on functional performance during the PRE session compared to control group. Contradictorily, prior studies revealed the use of rigid tape decreased in dorsiflexion and increased plantar flexion during landing (Delahunt et al., 2010), reduced maximal inversion and lateral inclination while standing above the platform, and it can increase ankle muscular support during unexpected inversion fluctuations (Briem et al., 2011).

This study was limited to male soccer players from an elite group, still no measurement that associated between the player's position were taken, which can apply for the future study. Furthermore, future studies

should include a diverse group of elite youth soccer players from various schools. In addition, different schools or football academies use various training programmes, which influence other physiological attributes and skill proficiency. Further research should limit familiarisation to two or three days before the actual test, rather than a week in advance to minimise the learning effect element during the actual test.

Conclusion

In conclusion, rigid tape improved functional performance and dynamic balance in both the PL (posterior-lateral) and PM (posterior-medial) directions compared to the control group. Fatigue decreases normalized reach distances in both directions and increases the YBT composite score. These data indicate that fatigue impairs dynamic balance, which may increase sports injury risk. However, rigid tape minimized fatigue's negative effects on performance. This study will be beneficial to youth soccer players, coaches, and interdisciplinary teams about rigid tape's benefits for unstable ankles. It investigates how rigid tape can improve dynamic balance and functional performance after game fatigue. These individuals and groups will benefit from this expertise. Rigid tape improves functional performance and dynamic balance, especially in the PL and PM orientations, compared to the control group. This data helps soccer players identify and manage fatigue-related ankle ailments.

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Conflicts of interest

The author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

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