Objective. Sport-specific functional tests were used to assess the power, speed, and agility of the lower extremity for a specific sport, but comparison of the differences and association with sport injury was rare. The aim of this study was to investigate the differences in sport-specific functional tests between junior basketball and soccer athletes and analyze the sport injury risk and occurrences.

Methods. All participants were evaluated using the sprint test, vertical jump (VJ) test, agility T test, and functional movement screen (FMS). There were significant intergroup differences in the sprint test, VJ test, agility T test, and FMS. Specific functional tests were compared against FMS score, either FMS ≤ 14 or FMS > 14. The FMS subtests, namely, in-line lunge, trunk stability push-up (TSPU), and quadruped rotary stability, were also performed. In one-year follow-up, the sport injury incidence was also recorded.

Results. Significant differences in sprint, agility, and FMS performance were found between the junior basketball and soccer athletes. Individual FMS scores of the in-line lunge, TSPU, and quadruped rotary stability were evaluated. No significant differences in sprint, VJ, and agility scores were found between FMS ≤ 14 and FMS > 14. FMS total score ≤ 14 was significantly associated with high sport injury occurrence.

Conclusions. The scores of sprint, agility, and FMS performance were differed between basketball and soccer athletes. The scores of sprint, VJ, and agility tests did not have differences with sport injury risks and occurrences, but the FMS score was associated with sport injury occurrence.

1. Introduction

The age- and skill-matched controls highlighted early differentiation in junior athletes [1]. Assessing athletes’ strengths and weaknesses by functional tests could help in prescribing appropriate training, conditioning, and lifestyle interventions. It is essential for optimal athlete development in the context of youth sports [2]. In professional basketball and soccer, athletes were faced with various technical demands and were also required a higher physical fitness [3]. A functional test was used to assess the combined physical fitness and technical performance. It was a sport-specific assessment focused on identifying physical fitness and match performance in a sport [4]. The sprint, jump, and agility tests were sport-specific functional tests, validating the match performances of basketball and soccer athletes. They could assess the power, speed, and agility of the lower extremity for a specific sport [3, 5]. Sprint test, vertical jump test, agility T test, and functional movement screen (FMS) were common sport-specific functional testing tools for basketball and soccer athletes [3, 5, 6]. In a previous study, the functional tests were used to assess match performances, but the usage of the tests for sport injury assessment was rare except functional movement screen [7]. Chalmers et al. have indicated that lower vertical jump, sprint, and agility were associated with an increased risk of various injuries and greater injury severity [8].

The most common ball sports among junior athletes are basketball and soccer, and these have a high rate of sport injuries in boys and girls [9]. There were a variety of sport injury factors, and intrinsic personal fitness and extrinsic environment caused sport injuries in up to 50~70% [10]. Sport development in these junior athletes should focus primarily on fitness performance and sport injury prevention. However, few studies focused on the use of sport-specific functional tests to compare the differences and association
with sport injury in junior basketball and soccer athletes. More studies are also required to analyze sport-specific functional tests in various sport teams as well as the differentness between sport injury risk and occurrences in the junior athletes. The aim of this study was to investigate the differences in sport-specific functional tests for junior athletes between basketball and soccer games and analyze the sport injury risk and occurrences. We hypothesized that there are no differences in sport-specific functional tests in junior basketball and soccer athletes, but higher sport injury risk had poor functional test scores and higher sport injury occurrences.

2. Methods

This is a prospective observational study, and participants were enrolled from the basketball and soccer teams of two junior high schools. Junior athletes who had participated in team practice and competition for more than one year and continued to join team practice were eligible for inclusion in the study. The exclusion criteria were athletes who had sustained severe injuries; had a history of neuromuscular or cardiovascular diseases; had undergone surgery; and had visual, vestibular, or balance problems that could affect their performance. This study was approved by the institutional review board. In accordance with the study of Cosio-Lima et al. [11], the sample size was estimated to be at least 31 participants in each group. Seventy-eight participants were included in this study. The participants’ data were grouped into two based on the sport terms: soccer team (Group 1, n = 34) and basketball team (Group 2, n = 44). All of them underwent four sport-specific functional tests, i.e., sprint test, VJ test, agility T test, and functional movement screen, which were used to conduct in a randomized order. At least a 20-minute break between each test was employed. A physical therapist conducted a one-on-one assessment of each participant. In one-year follow-up, the sport injury incidence was calculated via physical therapy reports of the number of athletes who suffered any sport injuries during the academic year. This study was approved by the Institutional Review Board of AT Hospital, and all participants were informed of study procedures prior to their participation.

3. Sport-Specific Functional Tests

3.1. Sprint Test. The wireless electronic timing gates system (Timing Gates System, You-Shang Technical Corp., Taiwan) was used for the sprint test, consisting of four distances of 10, 20, 30, and 40 m for a maximum of three straight-line sprints (Figure 1). The participants stood 0.5 m behind the starting line before they commenced each sprint, starting from a standing position. Active dynamic stretches of 3 min were performed during the warm-up. The physical therapist stood at the terminal line with a hand-held stopwatch and gave the “start” command to the participants. Tests were started with a distance of 10 m followed by a 5 min rest before the next sprint. The fastest sprint time was recorded for analysis. The sprint test has high reliability (intraclass correlation coefficient, ICC = 0.81; 90% confidence interval, CI = 0.64 ~ 0.90) and assesses the straight-line sprint performance of athletes [12].

3.2. Vertical Jump Test. The Vertec vertical jump meter (Sports Imports Incorporated, Columbus, OH, USA) was used for the VJ test (Figure 2(a)). With their hands smeared in chalk dust, the participants stood in front of a wall and were asked to raise their hands to reach as high as possible. The physical therapist marked the highest point reached on the wall and then asked the participants to jump vertically as high as possible to touch as high as possible on the wall. Strong verbal encouragement was provided during all tests to motivate the participants to exercise maximum effort. The difference between the two marked heights represented the VJ height. The participants performed the VJ test three times, and the highest height was selected. The VJ test is used to assess leg strength and has high reliability (ICC = 0.99; 95% CI = 0.98 ~ 0.99) in adolescent athletes [13].

3.3. Agility T Test. The wireless electronic timing system (T Test Agility Timing Systems, You-Shang Technical Corp., Taiwan) was used to measure the agility performance (Figure 2(b)). Participants were instructed to sprint forwards 10 m from cone A to cone B, touch the base of cone B, and then side shuffle 5 m to the left and touch the base of cone C. Then, they returned to the midline maintaining a forward facing position and repeated the sequence on the opposite side of the course to touch the base of cone D before running 10 m backward to the finish. The participants were asked to avoid crossing their legs during the side shuffle. Agility was determined based on the recorded time. The agility T test is used to test limb power, agility, and leg endurance and has high test-retest reliability (ICC = 0.94) [14].
3.4. Functional Movement Screen. The FMS comprises seven tests, and each test is scored on an ordinal scale of 0–3. The FMS™ (http://FunctionalMovement.com, Danville, VA, USA) tool was used to measure the functional movement performance (Figure 3). Participants should complete a deep squat, hurdle step, in-line lunge, shoulder mobility, ASLR, TSPU, and quadruped rotary stability test. If the participant performs the tested movement without any compensation, a score of 3 is given. If the movement is performed with compensation, a score of 2 is given. A score of 1 is given if the participant is unable to perform the movement, and a score of 0 is given if pain occurs during the movement. The maximum possible FMS score is 21, and a score of FMS ≤ 14 indicates a high risk of sport injury [15]. FMS is used to assess movement patterns and injury risk, and it has high interrater reliability (ICC = 0.90) [16].

3.5. Statistical Analysis. SPSS (version 20, IBM, NY, USA) was used for statistical analysis. Descriptive statistics for each parameter were presented as mean ± standard deviation. An independent t-test was used for multiple comparisons of all parameters among the two groups. High (FMS ≤ 14) or low (FMS > 14) risk of sport injury was compared in the sub-group analysis. An independent t-test was also used to compare the intergroup differences. Chi-square and OR were used to analyze the association with sport injury risk and
occurrence. The sport injury incidence in one-year follow-up used regression analyses to assess the OR. The significance level was set at \( p < 0.05 \).

4. Results

Of the 78 adolescent athletes included for statistical analysis (Figure 4), 34 athletes were in the soccer team (age = 16.31 ± 0.13 years, height = 148.63 ± 6.37 cm, and weight = 38.73 ± 5.83 kg) and 44 athletes were in the basketball team (age = 16.28 ± 0.38 years, height = 163.63 ± 8.04 cm, and weight = 53.23 ± 11.43 kg). Table 1 shows the timed scores of the sprint tests (30 and 40 m) and agility T test, which were significantly higher in Group 1 than in Group 2 (\( p < 0.05 \)). The FMS total score of Group 1 was significantly lower than that of Group 2 (\( p < 0.05 \)). Intergroup comparison revealed significant differences in the scores for in-line lunge, TSPU, and quadruped rotary stability (\( p < 0.05 \); Table 2). Subgroup analysis revealed no significant differences in the sprint, VI, and agility T test scores between high (FMS total score \( \leq 14 \)) and low (FMS total score > 14) risk of sport injury (\( p < 0.05 \); Table 3).

During the one-year follow-up, there were 15 and 16 junior athletes in Group 1 (44.12%) and Group 2 (36.37%), respectively, who reported occurrences of sport injuries (Table 4). In Groups 1 and 2, no significant differences on sprint, VI, and agility T test scores between noninjured and injured athletes were observed. The score of total FMS in noninjured athletes was significantly higher than that in injured athletes (Group1, \( p = 0.002 \); Group2, \( p = 0.02 \)), respectively. The multivariate analysis showed no significant association among the sprint, VI, agility T test, and FMS scores (\( p > 0.05 \)). But the univariate analyses showed a significant association between total FMS score and the occurrence of sport injuries (Group 1, OR = 0.30, 95%CI = 0.09-0.93, \( p = 0.03 \); Group 2, OR = 0.48, 95%CI = 0.23-1.01, \( p = 0.04 \)).

Of the 20 junior athletes with FMS total score \( \leq 14 \) in Group 1, 13 athletes (65%) had sport injury, but 7 athletes (35%) did not have sport injury. And of the 14 junior athletes with FMS total score > 14, 4 athletes (29%) had sport injury, but 10 athletes (71%) did not have sport injury. In the soccer athletes, high sport injury risk (FMS total score \( \leq 14 \)) was significantly associated with high sport injury occurrence (OR = 0.22, 95%CI = 0.05 - 0.94). Of the 18 junior athletes with FMS total score \( \leq 14 \) in Group 2, 12 athletes (89%) had sport injury, but 6 athletes (11%) did not have sport injury.

Table 1: Outcomes of sprint test, vertical jump test, agility T test, and FMS between 2 groups.

| Items                    | Group 1 (n = 34) | Group 2 (n = 44) | \( p \) value |
|--------------------------|-----------------|-----------------|--------------|
| Sprint test (10 m)       | 2.51 ± 0.27     | 2.45 ± 0.18     | 0.47         |
| Sprint test (20 m)       | 4.17 ± 0.52     | 3.91 ± 0.28     | 0.46         |
| Sprint test (30 m)       | 5.74 ± 0.81     | 5.31 ± 0.45     | 0.04*        |
| Sprint test (40 m)       | 7.16 ± 0.74     | 6.70 ± 0.59     | 0.03*        |
| Vertical jump test       | 42.75 ± 6.06    | 44.45 ± 8.98    | 0.51         |
| Agility T test           | 13.21 ± 1.23    | 12.22 ± 1.21    | 0.01*        |
| FMS total score          | 11.35 ± 2.34    | 13.64 ± 1.94    | 0.01*        |

Table 2: Outcomes of 7 items in FMS between two groups.

| Items                        | Group 1 (n = 34) | Group 2 (n = 44) | \( p \) value |
|------------------------------|-----------------|-----------------|--------------|
| FMS                          |                 |                 |              |
| Deep squat                   | 1.65 ± 0.78     | 1.86 ± 0.54     | 0.32         |
| Hurdle step                  | 1.52 ± 0.62     | 1.82 ± 0.39     | 0.08         |
| In-line lunge                | 1.24 ± 0.83     | 1.73 ± 0.55     | 0.03*        |
| Shoulder mobility            | 1.87 ± 0.99     | 1.76 ± 0.97     | 0.73         |
| Active straight leg raise    | 1.82 ± 0.56     | 1.95 ± 0.58     | 0.47         |
| Trunk stability push-up      | 1.82 ± 1.19     | 2.77 ± 0.61     | 0.01*        |
| Quadruped rotary stability   | 1.41 ± 0.87     | 1.73 ± 0.46     | 0.01*        |
injury. And of the 26 junior athletes with FMS total score $>14$, 4 athletes (15%) had sport injury, but 22 athletes (85%) did not have sport injury. In the basketball athletes, high sport injury risk (FMS total score $\leq 14$) was also significantly associated with high sport injury occurrence (OR = 0.99, 95% CI = 0.92 - 0.99). Of all the junior athletes ($n = 78$), those with FMS total score $\leq 14$ had higher sport injury occurrence (OR = 0.13, 95%CI = 0.04 - 0.36). The junior athletes with FMS total score $\leq 14$ had higher prevalence of sport injury occurrence in Group 1 ($\chi^2 = 4.37, p = 0.04$) and Group 2 ($\chi^2 = 12.09, p = 0.01$).

5. Discussion

This study was designed to compare the sport-specific functional tests between junior basketball and soccer athletes and determine the sport injury risk and occurrences. Significant differences in 30 m and 40 m sprint test, agility T test, and FMS total score were found between both groups ($p < 0.05$). Comparing individual items of FMS in both groups, the items of in-line lunge, trunk stability push-up, and quadruped rotary stability had significant differences ($p < 0.05$). However, there were no significant differences in scores of the sprint test, vertical jump test, and agility T test between high and low sport injury risks in both groups. In one-year follow-up, a significant difference in total score of FMS was found between noninjured and injured athletes ($p < 0.05$), but the scores of the sprint test, vertical jump test, and agility T test did not have significant differentness ($p > 0.05$).

The current study results found that compared with adolescent soccer athletes, adolescent basketball athletes had better sport performance in physical fitness, including sprint, VJ, and agility. Basketball involves high-intensity movements, such as turning, jumping, and sprinting [17]. Soccer also requires a high level of physical fitness, especially in terms of strength, power, and speed [18]. Nonetheless, the current study found that compared with adolescent basketball athletes, adolescent soccer athletes performed poorly in sprint and agility tests.

The FMS is a popular functional testing tool and comprises seven subtests that focus on assessing competency in movement, mobility, and stability. These tests are the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise (ASLR), trunk stability push-up (TSPU), and rotary stability [19]. An indicator of movement quality is the presence of asymmetry in subtests upon comparison of the movements performed on both sides of the body, which are the hurdle step, in-line lunge, shoulder mobility, ASLR, and rotary stability [19]. Moreover, the relationship between prospective injury and an FMS composite score of $\leq 14$ has been widely reported. But Bardenett et al. thought less evidence proved that FMS composite score of $\leq 14$ was associated with an increased sport injury risks in youth athletes of ages 8 to 21 years [20]. However, Pfeifer et al. thought that FMS is an applicable tool to identify dysfunctional movement for junior athletes [21]. FMS also could be used to predict sport injury risk for junior athletes (odds ratio, OR = 1.71) [22]. Assessing the predictive utility of FMS in junior athletes is still important, when they were still

### Table 3: Comparison of sprint, vertical jump, and agility tests between FMS $\leq 14$ and FMS $>14$.

| Items               | FMS $\leq 14$ ($n = 20$) | FMS $>14$ ($n = 14$) | FMS $\leq 14$ ($n = 18$) | FMS $>14$ ($n = 26$) |
|---------------------|---------------------------|----------------------|--------------------------|----------------------|
| Sprint test (10 m)  | 2.52 ± 0.22               | 2.40 ± 0.12          | 2.44 ± 0.13              | 2.45 ± 0.21          |
| Sprint test (20 m)  | 4.23 ± 0.51               | 3.85 ± 0.37          | 3.88 ± 0.25              | 3.93 ± 0.30          |
| Sprint test (30 m)  | 5.83 ± 0.86               | 5.33 ± 0.26          | 5.23 ± 0.43              | 5.36 ± 0.47          |
| Sprint test (40 m)  | 7.19 ± 0.81               | 6.99 ± 0.21          | 6.58 ± 0.50              | 6.78 ± 0.65          |
| Vertical jump test  | 42.83 ± 6.67              | 42.46 ± 2.15         | 45.25 ± 5.93             | 43.88 ± 10.82        |
| Agility T test      | 13.24 ± 1.12              | 13.04 ± 1.95         | 12.14 ± 0.92             | 12.27 ± 1.41         |

### Table 4: Regression analyses of sprint, vertical jump, and agility tests and FMS of sport injury.

| Items               | Noninjured ($n = 19$) | Group 1 Injured ($n = 15$) | OR* | Noninjured ($n = 28$) | Group 2 Injured ($n = 16$) | OR* |
|---------------------|-----------------------|-----------------------------|-----|-----------------------|-----------------------------|-----|
| Sprint test (10 m)  | 2.47 ± 0.21           | 2.51 ± 0.31                 | 1.77| 2.44 ± 0.19           | 2.46 ± 0.16                 | 2.34|
| Sprint test (20 m)  | 3.98 ± 0.33           | 4.30 ± 0.57                 | 4.96| 3.90 ± 0.26           | 3.95 ± 0.35                 | 1.97|
| Sprint test (30 m)  | 5.58 ± 6.37           | 5.85 ± 0.93                 | 1.57| 5.28 ± 0.40           | 5.36 ± 0.59                 | 1.44|
| Sprint test (40 m)  | 7.18 ± 0.69           | 7.14 ± 0.80                 | 0.92| 6.71 ± 0.59           | 6.68 ± 0.62                 | 0.91|
| Vertical jump test  | 43.82 ± 1.88          | 42.20 ± 7.83                | 0.94| 44.41 ± 10.21         | 44.53 ± 5.19                | 1.01|
| Agility T test      | 13.04 ± 1.26          | 13.33 ± 1.25                | 1.23| 12.16 ± 1.29          | 12.36 ± 1.04                | 1.15|
| Total FMS           | 13.28 ± 1.79          | 10.01 ± 1.63**              | 0.30**| 14.18 ± 1.91          | 12.16 ± 1.16**              | 0.48**|

*aUnivariate analyses; *p < 0.05, noninjured vs. injured; **p < 0.05, significant association; OR: odds ratio."
physically maturing and have potential skill development
[21]. Moreover, the adolescent soccer athletes demonstrated
poor functional performance on FMS assessment in the
current study. The reasons for these differences in physical
fitness may probably be attributed to the differential anthro-
pometric characteristics of each sport [23]. Moreover, the
differences in physical fitness could be from the differences
in selection criteria of athletes for soccer and basketball
[24]. Our study found the soccer athletes to have poor ath-
etic performance. Upon analysis of the FMS subtests, the
scores of the soccer athletes in three tests, i.e., the in-line
lunge, TSPU, and quadruped rotary stability, were lower than
those of the basketball athletes.

Movement proficiency barrier (score of individual
item $\leq 2$) during FMS testing, and not the composite score,
can be used to identify junior athletes at an increased risk
of prospective injury. Notably, among 237 elite junior
male Australian football athletes, sport injury occurrence
of the athletes with movement proficiency barrier was
threefold and increased in the risk of an injury to require
a missed game (hazard ratio = 3.7; relative risk = 2.8) [25]. In
the current study, numbers of scores of total FMS $\leq 14$ were
20 (59%) and 18 (41%), and numbers of junior basketball
and soccer athletes having sport injuries were 15 (44%) in
soccer and 16 (36%) in basketball, respectively. We also
found that average scores of individual FMS item in both
groups were less than 2, and low total FMS score had higher
sport injury occurrence. A previous study reported that a
high percentage (65%) of elite junior Australian football ath-
etes exhibited at least one individual item score $\leq 2$ during
FMS testing [26]. The athletes who reported an injury in the
previous season were 1.5 times more likely to experience
pain during FMS testing, despite having no current injuries
[26]. Moran et al. indicated no association has been found
between dysfunctional movements of FMS composite score
of $\leq 14$ and injuries sustained by athletes in the previous sea-
son [27]. Therefore, because of the measurement bias associ-
ated with retrospective injury analysis, studies following up
athletes prospectively after FMS testing are necessary [26].

The TSPU and quadruped rotary stability tests in FMS
assess the static and dynamic stability of the trunk. Notably,
running-based sports require trunk rotation and stability to
increase sport energy transfer [28]. The agility T test and 30
and 40 m sprint tests assessed performance when running
and changing directions. The soccer team was found to have
poor agility and sprint performance in addition to poor func-
tional movement in our study. Lloyd et al. analyzed the rela-
tionship between FMS and physical fitness in young soccer
athletes (age $= 11 - 16$ years) [29]. They found that FMS
score had a significant negative correlation with agility
($r = -0.54$, $p < 0.05$). In addition, using regression analysis,
they found that the in-line lunge test is a primary predictive
variable to explain agility performance ($R^2 = 0.46$) [29]. The
in-line lunge requires postural control with equal bilateral
lower extremities and is both a static and dynamic task
[30]. Therefore, it is a fitting indicator of agility during rapid
change-of-direction movements [31]. Other studies also
supported that the in-line lunge and sprint speed can be used
to measure athletic performance [32, 33]. Therefore, our cur-
rent study was similar with previous outcomes, resulting in
poor sprint, agility, and FMS performance, especially the
in-line lunge, TSPU, and quadruped rotary stability, in the
junior soccer athletes.

Kiesel et al. proposed the cut-off point of FMS $\leq 14$ as
being more closely associated with sport injury risk [34].
The findings of Abraham et al. and Rusling et al. demon-
strated that average scores of composite FMS adolescent
and junior football athletes were 12.12–16.44 and were simi-
lar as our results [35, 36]. Bardenett et al. assessed FMS in 167
high school athletes (average age = 15.2 years) and found that
composite FMS scores of nonsport injured and sport injured
were $13.11 \pm 1.69$ and $13.00 \pm 2.32$, respectively [20]. The
data of composite FMS scores were similar to that of our
nonsport injured junior athletes, but differ from sport injured
junior athletes. The sport characteristics of participants in the
current study were basketball and soccer, and it may cause
the different sport injury occurrences. A previous systematic
review and meta-analysis indicated that FMS scores are rele-
vant in sport injury occurrences [37]. Notably, an athlete
with an FMS $\leq 14$ was found to have 2.74 times higher risk
of injury risk than those with an FMS $> 14$ [37]. In this study,
the comparison of soccer and basketball athletes with FMS
$\leq 14$ and FMS $> 14$ revealed no significant differences in
terms of sprint, VJ, and agility. The athletes with higher
injury risk did not demonstrate any differences in their phys-
ical fitness compared with the athletes with lower injury risk.
FMS is a cumulative score of multiple tests that can assess
posture and balance deficits [38]. However, sprint, VJ, and
agility performance represents gross motor skills. Classifica-
tion of sport injury risk cannot observe differences in physi-
cal fitness.

The clinical implications for this study are that sport-
specific functional tests could be used to compare the differ-
ences of physical fitness and sport injury in junior basketball
and soccer athletes. Sprint test, VJ test, and agility T test were
not applicable to identify sport injury occurrence in junior
basketball and soccer athletes except FMS. Our study had
some limitations. First, all the adolescent athletes were from
the basketball and soccer teams of two schools, representing
only a small portion of the adolescent population. Second,
the severity data of sport injuries were not collected during
follow-up. Therefore, future studies should adopt larger sam-
ple sizes or involve different types of ball games along with the
exploration of the occurrence of sport injury.

6. Conclusions

This study investigated the differences in sport-specific func-
tional tests between junior basketball and soccer athletes and
compared the differences between high and low sport injury
risks. Differences in the scores of sprint, agility, and FMS per-
f ormance were found between basketball and soccer athletes.
Furthermore, the two kinds of athlete were found to dem-
strate differences in in-line lunge, TSPU, and quadruped
rotary stability of FMS, possibly because of the differential
anthropometric characteristics of each specific sport. No
differences in scores of sprint, VJ, and agility test were found
in different sport injury risks or different sport injury
occurrences. The FMS score was associated with sport injury occurrence and could be an indicator of sport injury risk.

Data Availability
The data used to support the findings of this study are included within the article.

Disclosure
No funder support was involved in the manuscript writing, editing, approval, or decision to publish.

Conflicts of Interest
The authors declare that they have no conflicts of interest.

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