

Functional Movement Quality and Self-Reported Injury History in Adolescent Volleyball Players: A Retrospective Cross-Sectional Study

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Abstract

The Functional Movement Screen (FMS) is widely used in youth sport, but the value of its composite score in adolescents is uncertain. This retrospective cross-sectional study described FMS performance, injury prevalence and regional pain in adolescent volleyball players and compared FMS composite and item scores between players with and without self-reported injury in the previous 12 months. Twenty-three competitive volleyball players (21 female; 13–18 years) completed the FMS and an online questionnaire adapted from the Oslo Sports Trauma Research Center instruments, reporting injuries in the previous 12 months and shoulder, lower back and knee pain intensity in the previous 3 months. The mean FMS composite score was 16.61 ± 2.19 ; the in-line lunge had the lowest item score (1.87 ± 0.55), whereas shoulder mobility, active straight-leg raise and rotary stability showed ceiling effects. Injury was reported by 34.8% of players (95% confidence interval [CI] 18.8–55.1%). Knee pain was the most frequent complaint (60.9%; 95% CI 40.8–77.8%), followed by lower back (43.5%) and shoulder pain (26.1%). Composite scores did not differ significantly between injured and uninjured players (16.62 ± 2.72 vs 16.60 ± 1.96 ; $p=0.980$; Hedges' $g=0.01$, 95% CI -0.85 to 0.87), and no item score differed between groups ($p=0.210$ – 1.000). In this sample, no statistically significant differences in FMS scores were detected between players with and without recent injury; given the small sample and wide confidence intervals, a moderate association cannot be excluded. Knee complaints were highly prevalent; assessment of individual movement patterns and region-specific symptom monitoring may complement each other, and larger prospective studies are needed.

Keywords: mass screening · youth sports · cumulative trauma disorders · musculoskeletal pain · low back pain · sports medicine

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Introduction

Sports injuries are a major concern in athletes aged 12–18 years, a period of rapid growth and substantial change in the musculoskeletal system and movement coordination. Growth cartilage and apophyseal insertions tolerate mechanical stress less well than mature bone, which predisposes adolescents to age-specific overuse conditions (Adirim & Cheng, 2003). High training volume, inadequate load management and early specialisation further increase injury risk (Borkowski et al., 2025; McGowan et al., 2020), and in girls the onset of maturation is accompanied by reduced dynamic knee control during landing (Hewett et al., 2004).

Volleyball involves repeated jumping, landing and rapid changes of direction, together with high shoulder loads during spiking and serving. Ankle, knee and shoulder injuries are the most common injuries in the sport (Kilic et al., 2017), and volleyball has one of the highest prevalences of patellar tendinopathy among jumping sports (Lian et al., 2005). Many of these conditions develop gradually and are not captured by time-loss injury definitions (Clarsen et al., 2013).

The Functional Movement Screen (FMS) consists of seven standardised movement patterns scored from 0 to 3 and is designed to identify limitations in mobility and stability, compensatory movement and left–right asymmetry (Cook et al., 2014a, 2014b). A composite score ≤ 14 was originally proposed as a threshold for serious injury in professional American football players (Kiesel et al., 2007). Meta-analyses have confirmed good reliability (Bonazza et al., 2017) but found weaker associations with injury in junior than in senior athletes (pooled odds ratio 1.03 vs 1.80) and in females (Asgari et al., 2021; Moore et al., 2019). Screening tests in general lack the accuracy required to predict individual injury (Bahr, 2016), and in adolescents FMS scores also depend on biological maturation (Portas et al., 2016) and vary widely (O'Brien et al., 2022).

Evidence specific to youth volleyball is limited. A lower composite score predicted in-season injury in a prospective cohort of youth volleyball players (Zarei et al., 2022), and young male football players with previous injury had lower composite scores than their uninjured peers (Łyp et al., 2022). Most studies, however, have relied on the composite score alone, although item-level scores may reflect specific movement deficits (Koźlenia & Domaradzki, 2021; Read et al., 2016). Few studies have also considered region-specific pain, which captures the overuse complaints typical of volleyball (Clarsen et al., 2020; Lian et al., 2005).

The aim of this study was to describe FMS performance, injury prevalence and regional pain in adolescent volleyball players, and to examine whether FMS composite and item scores differ between players with and without self-reported injury in the previous 12 months. It was hypothesised that players with a history of injury would have lower FMS scores.

Method

Study design and participants

This retrospective cross-sectional study is reported in accordance with the STROBE guidelines (von Elm et al., 2007). Movement screening and the questionnaire were completed at a single time point, whereas injury history and pain were reported retrospectively. The design therefore examines associations between current movement quality and past injury, not prospective injury risk. Participants were not sampled on the basis of injury status. Data were collected at five volleyball clubs in Serbia and Bosnia and Herzegovina from April to May 2026. Twenty-three adolescent volleyball players (21 female, 2 male) aged 13–18 years (15.35 ± 1.19 years) participated; 17 (73.9%) competed at the national and 6 (26.1%) at the municipal level. Inclusion criteria were age 12–18 years, volleyball as the primary sport and regular organised volleyball training for at least 3 years. Players were recruited by convenience sampling, and no a priori sample size calculation was performed. A minimal detectable effect calculation showed that, with $\alpha=0.05$ and power of 0.80, the sample allowed detection of between-group differences of $d \geq 1.29$ (8 vs 15 players).

This study was approved in advance by the Ethics Committee of the Faculty of Sport and Physical Education, University of Novi Sad (approval no. 52-10-19/2026-1), and was conducted in accordance with the Declaration of Helsinki. A parent or legal guardian of each participant voluntarily provided written informed consent, and each participant gave assent.

Functional movement screen

Movement quality was assessed with the FMS according to the standard protocol (Cook et al., 2014a, 2014b): deep squat, hurdle step, in-line lunge, shoulder mobility, active straight-leg raise (ASLR), trunk stability push-up (TSPU) and rotary stability. All tests were administered and scored by one examiner holding FMS Level 2 certification, with 5 years of experience in movement screening of athletes. The FMS has shown good intra- and inter-

rater reliability (Bonazza et al., 2017). After a brief warm-up, each test was performed three times and the best attempt was scored: 0, pain during the movement; 1, inability to complete the pattern; 2, completion with compensation; 3, correct performance. For the five bilateral tests (hurdle step, in-line lunge, shoulder mobility, ASLR and rotary stability), both sides were tested and the lower score was recorded. The shoulder clearing, spinal extension clearing and spinal flexion clearing tests were performed after the shoulder mobility, trunk stability push-up and rotary stability tests, respectively, and a positive clearing test (pain) resulted in a score of 0 for the associated test (Cook et al., 2014b); no player had a positive clearing test. For rotary stability, a score of 3 required a correct same-side (unilateral) repetition and a score of 2 a correct diagonal repetition, as specified in the protocol (Cook et al., 2014b). The composite score was calculated as the sum of the seven test scores (range 0–21).

Injury and pain questionnaire

Injury history and complaints were recorded with an online questionnaire developed for this study, with items adapted from the Oslo Sports Trauma Research Center (OSTRC) questionnaires (Clarsen et al., 2013, 2020), the Youth Overuse Injury Questionnaire (Lau & Mukherjee, 2024) and previous work on sport specialisation in children (McGowan et al., 2020). Its 38 items covered five domains: demographics; sport history and training volume; injuries in the previous 12 months (number, type, location and consequences); overuse complaints in the shoulder, lower back and knee in the previous 3 months; and potential risk factors (warm-up, stretching, sleep, recent growth spurt, previous injury and training despite pain). An injury was defined as tissue damage or other derangement of normal physical function due to participation in volleyball, resulting from rapid or repetitive transfer of kinetic energy (Bahr et al., 2020). Any such injury reported by the player was counted, irrespective of the need for medical attention or time loss, and its type (acute, gradual-onset or both), location and consequences for training were recorded. Players who reported at least one injury in the previous 12 months were classified as injured ($n=8$), and all other players as uninjured ($n=15$). Players rated the highest pain intensity experienced in each region during the previous 3 months using four response categories anchored to a 0–10 numerical rating scale: no pain, mild (1–3), moderate (4–6) or severe (≥ 7). The questionnaire was administered in Serbian.

Statistical analysis

Data are presented as mean $\pm$ standard deviation (SD), median and range, or as frequencies with 95% confidence intervals (CI; Wilson method). Normality of the composite score was checked with the Shapiro–Wilk test and homogeneity of variances with Levene's test. Players with and without injury in the previous 12 months were compared with an independent-samples t-test for the composite score (effect size Hedges' g with 95% CI) and with the Mann–Whitney U test for the ordinal item scores (effect size rank-biserial correlation, r_{rb}). Effect sizes were interpreted as trivial (<0.20), small (0.20), medium (0.50) and large (0.80) for g , and as small (0.10), medium (0.30) and large (0.50) for r_{rb} . Because sex differences in maturation and landing mechanics may affect movement screening, all group comparisons were repeated after excluding the two male players ($n=21$). The minimal detectable effect (two-tailed $\alpha=0.05$, power 0.80) was calculated to determine the smallest between-group difference detectable with the available sample. Significance was set at $p<0.05$ (two-tailed). Analyses were performed in IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA); Wilson confidence intervals, effect sizes and their confidence intervals were calculated using standard formulas.

Results

Most players had 5–6 years of volleyball experience and trained three times per week (Table 1). The mean composite score was 16.61 ± 2.19 (median 17; range 12–20).

Table 1. Demographic and Sport Characteristics of the Sample ($n=23$)

Variable	Category	n (%) or M $\pm$ SD
Sex	Female	21 (91.3)
	Male	2 (8.7)
Age (years)		15.35 $\pm$ 1.19
Competition level	National	17 (73.9)
	Municipal	6 (26.1)
Volleyball experience	3–4 years	8 (34.8)
	5–6 years	14 (60.9)
	≥ 7 years	1 (4.3)
	2	1 (4.3)
Training sessions per week	3	12 (52.2)
	4	3 (13.0)
	≥ 5	7 (30.4)

Note. M $\pm$ SD, mean $\pm$ standard deviation.

The in-line lunge had the lowest mean score, with 5 players (21.7%) scoring 1, whereas shoulder mobility, ASLR and rotary stability showed a ceiling

effect, with 78.3% of players achieving the maximum score (Table 2). No player scored 0.

Table 2. Functional Movement Screen Item and Composite Scores (n=23)

FMS test	M±SD	Median (range)	Score 1, n (%)	Score 2, n (%)	Score 3, n (%)
Deep squat	2.00±0.60	2 (1–3)	4 (17.4)	15 (65.2)	4 (17.4)
Hurdle step	2.00±0.52	2 (1–3)	3 (13.0)	17 (73.9)	3 (13.0)
In-line lunge	1.87±0.55	2 (1–3)	5 (21.7)	16 (69.6)	2 (8.7)
Shoulder mobility	2.70±0.63	3 (1–3)	2 (8.7)	3 (13.0)	18 (78.3)
ASLR	2.78±0.42	3 (2–3)	0 (0.0)	5 (21.7)	18 (78.3)
TSPU	2.48±0.67	3 (1–3)	2 (8.7)	8 (34.8)	13 (56.5)
Rotary stability	2.78±0.42	3 (2–3)	0 (0.0)	5 (21.7)	18 (78.3)
Composite score	16.61±2.19	17 (12–20)	–	–	–

Note. No player scored 0 (pain). FMS, Functional Movement Screen; ASLR, active straight-leg raise; TSPU, trunk stability push-up.

Eight players (34.8%; 95% CI 18.8–55.1%) reported an injury in the previous 12 months: three reported one injury, three reported two and two reported three. Five players reported both acute and gradual-onset injuries, two acute injuries only and one a gradual-onset injury only. The knee was the most frequently injured site (n=5), followed by the ankle (n=3), foot or toes (n=3) and shoulder (n=2). Five

injured players continued to train and compete despite injury, two reduced training volume or intensity and one stopped training and competition completely. Knee pain was the most frequent complaint (60.9%), followed by lower back (43.5%) and shoulder pain (26.1%); moderate-to-severe pain was reported by 39.1% of players for the knee, and severe pain occurred only in the knee (Table 3).

Table 3. Prevalence of Injury and Pain Intensity by Body Region (n=23)

Outcome	n (%)	95% CI (%)
Injury in previous 12 months	8 (34.8)	18.8–55.1
Shoulder pain, any	6 (26.1)	12.5–46.5
Mild / moderate / severe	4 (17.4) / 2 (8.7) / 0 (0.0)	–
Lower back pain, any	10 (43.5)	25.6–63.2
Mild / moderate / severe	7 (30.4) / 3 (13.0) / 0 (0.0)	–
Knee pain, any	14 (60.9)	40.8–77.8
Mild / moderate / severe	5 (21.7) / 6 (26.1) / 3 (13.0)	–

Note. Pain refers to the previous 3 months, reported in categories anchored to a 0–10 scale: mild, 1–3; moderate, 4–6; severe, ≥7. CI, confidence interval (Wilson method).

The composite score was normally distributed in the whole sample ($W=0.952$, $p=0.322$) and in both groups (injured: $W=0.946$, $p=0.667$; uninjured: $W=0.961$, $p=0.714$), and variances were homogeneous (Levene's $F=1.64$, $p=0.215$). Composite scores were almost identical in players with and without injury in the previous 12 months (16.62 ± 2.72 vs 16.60 ± 1.96 ; $t(21)=0.03$, $p=0.980$), with a trivial effect size ($g=0.01$, 95% CI -0.85 to 0.87). None of the seven FMS tests differed significantly between groups ($p=0.210$ – 1.000 ; Table

4). Mean scores were identical for the deep squat and hurdle step (2.00 in both groups; $r_{rb}=0.00$). Injured players scored slightly lower on the in-line lunge (1.75 ± 0.71 vs 1.93 ± 0.46 ; $r_{rb}=-0.18$) and shoulder mobility (2.50 ± 0.76 vs 2.80 ± 0.56 ; $r_{rb}=-0.23$), and slightly higher on the ASLR, rotary stability (both 2.88 ± 0.35 vs 2.73 ± 0.46) and TSPU (2.62 ± 0.52 vs 2.40 ± 0.74 ; $r_{rb}=0.14$ for all three). All item-level differences were small and inconsistent in direction.

Table 4. Functional Movement Screen Scores in Players With and Without Injury in the Previous 12 Months

FMS test	Injured (n=8) M±SD	Uninjured (n=15) M±SD	Statistic	p	Effect size
Deep squat	2.00±0.53	2.00±0.65	U=60.0	1.000	$r_{rb}=0.00$
Hurdle step	2.00±0.53	2.00±0.53	U=60.0	1.000	$r_{rb}=0.00$
In-line lunge	1.75±0.71	1.93±0.46	U=49.5	0.402	$r_{rb}=-0.18$
Shoulder mobility	2.50±0.76	2.80±0.56	U=46.0	0.210	$r_{rb}=-0.23$
ASLR	2.88±0.35	2.73±0.46	U=51.5	0.443	$r_{rb}=0.14$
TSPU	2.62±0.52	2.40±0.74	U=51.5	0.534	$r_{rb}=0.14$
Rotary stability	2.88±0.35	2.73±0.46	U=51.5	0.443	$r_{rb}=0.14$
Composite score	16.62±2.72	16.60±1.96	t(21)=0.03	0.980	g=0.01 (-0.85 to 0.87)

Note. Item scores, Mann–Whitney U test; composite score, independent-samples t-test with Hedges' g (95% confidence interval). Positive effect sizes indicate higher scores in injured players. ASLR, active straight-leg raise; TSPU, trunk stability push-up; r_{rb} , rank-biserial correlation.

After exclusion of the two male players (n=21; seven injured), no significant differences between groups were found for the composite score (17.29±2.14 vs 16.36±1.78; t(19)=1.06, p=0.304; g=0.47, 95% CI -0.45 to 1.39) or for any item score (p=0.125–0.920). In this subsample, the composite score was slightly higher in injured than in uninjured players.

Discussion

This study examined FMS performance, injury prevalence and regional pain in adolescent volleyball players. Neither the composite score nor any of the seven test scores differed significantly between players with and without injury in the previous 12 months in this sample, whereas knee pain was reported by six in ten players. The hypothesis was therefore not supported, although the small sample does not allow a moderate association to be ruled out.

The mean composite score (16.6) lay above the threshold of 14 points proposed in professional American football (Kiesel et al., 2007), and the difference between injured and uninjured players was close to zero. This contrasts with a prospective study in youth volleyball, in which a lower composite score predicted injury (Zarei et al., 2022), and with a retrospective study in which 12–13-year-old male football players with previous injury scored about 2.4 points lower than uninjured peers (Łyp et al., 2022). Because movement screening took place after the reported injuries, lower scores in injured players, had they been observed, could reflect either a pre-existing deficit or a consequence of injury and rehabilitation; the present design addresses association with injury history rather than

prediction. The present sample was small and predominantly female, injury was recalled retrospectively, and the study had power to detect only large differences; the wide confidence interval around g (-0.85 to 0.87) does not exclude a moderate true difference. When the two male players were excluded, the difference remained non-significant but changed direction (g=0.47 in favour of injured players), which further illustrates the instability of estimates in a sample of this size. The absence of a detectable difference is nevertheless consistent with meta-analytic evidence that the composite score has little predictive value in junior athletes and uncertain value in females (Asgari et al., 2021; Moore et al., 2019), and with the argument that a single screening score cannot separate individuals at high and low risk because their distributions overlap substantially (Bahr, 2016). Moreover, the threshold of 14 points was derived in adult men, whereas FMS scores in adolescents depend on maturation (Portas et al., 2016), and reference values for youth volleyball are lacking.

At the item level, differences between groups were small and inconsistent in direction: injured players scored slightly lower on the in-line lunge and shoulder mobility, but slightly higher on the ASLR, TSPU and rotary stability. Shoulder mobility, ASLR and rotary stability showed marked ceiling effects, with 78.3% of players achieving the maximum score, which restricts variance and limits the ability of these tests to discriminate between players. The in-line lunge, which challenges single-leg stability, hip and ankle mobility and frontal-plane knee control on a narrow base of support (Cook et al., 2014a), was the most frequently failed pattern. Deficits in single-leg tasks have been identified as

risk factors for knee and ankle ligament injury in youth football players (Read et al., 2016), and reduced dynamic knee control has been described in girls after the onset of maturation (Hewett et al., 2004). The cross-sectional design, however, does not allow conclusions about whether such deficits precede injury.

Knee pain was the most prevalent complaint, reported by 60.9% of players, and 39.1% reported moderate or severe knee pain in the previous 3 months. Knee complaints in the previous 3 months were thus more common than injuries reported for the previous 12 months, although the two measures used different definitions and recall periods and are not directly comparable. This agrees with the high knee loading of repeated jumping and landing and the high prevalence of patellar tendinopathy in volleyball (Kilic et al., 2017; Lian et al., 2005), and is consistent with the view that gradual-onset complaints may not be fully captured by injury registration alone (Clarsen et al., 2013, 2020).

The present data do not support using FMS scores to identify adolescent volleyball players with a history of injury. Regular region-specific symptom monitoring of the knee, lower back and shoulder, for example with OSTRC-type questionnaires (Clarsen et al., 2013, 2020), requires little time and, in this sample, identified a substantial burden of musculoskeletal complaints. FMS results are best used to profile movement quality and to individualise training content rather than to predict injury (Bahr, 2016). For strength and conditioning coaches, assessment of individual movement patterns and region-specific symptom questionnaires may therefore remain useful for profiling athletes and guiding training, even though the composite score did not identify players with injury history.

The study combined a standardised movement screen with region-specific symptom data and reported effect sizes with confidence intervals. Its limitations include the small convenience sample, which was almost exclusively female and from a single sport, so that the findings apply at best to adolescent female volleyball players, although excluding the two male players did not change the absence of significant differences. Injury history (12 months) and pain (3 months) were self-reported retrospectively. Long recall periods are associated with under-reporting of minor and gradual-onset problems, and adolescents may misremember the timing or nature of complaints; such misclassification between the injured and uninjured groups would most likely attenuate between-group differences. The questionnaire was not formally validated in Serbian. Biological maturation was not

assessed; left and right scores of the bilateral tests were not recorded separately, so side-to-side asymmetries could not be analysed; and three tests showed ceiling effects. The cross-sectional design precludes causal inference. Prospective studies in larger, sex-balanced cohorts should combine weekly OSTRC-based monitoring, quantification of training load (Hildebrandt et al., 2021; O'Keeffe et al., 2020), assessment of maturity status and analysis of item-level scores and asymmetries.

Conclusion

In adolescent volleyball players, neither the FMS composite score nor individual test scores differed significantly between players with and without self-reported injury in the previous 12 months in this sample; given the small sample, a moderate association cannot be excluded. Knee pain was highly prevalent, with moderate-to-severe complaints affecting almost four in ten players. FMS composite scores should not be used in isolation to identify injury history in this population. Assessment of individual movement patterns and region-specific symptom questionnaires, such as the OSTRC instruments, may nevertheless remain valuable tools for strength and conditioning coaches to profile athletes and individualise training.

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