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Functional Movement Screen® evaluation: comparison between elite and non-elite young swimmers

Evaluación Functional Movement Screen®: Comparación entre nadadores jóvenes de élite y no élite

Evaluación Functional Movement Screen®: Comparación entre nadadores jóvenes de élite y no élite

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ABSTRACT

Functional Movement Screen® (FMS®) allows to assess athlete's movement functionality. Movement funcionality in young elite and non-elite swimmers may predict future performance. The purpose of this study is to compare FMS® scores between young elite and non-elite swimmers, and to verify their relationship with 100m freestyle performance. Thirty-two elite swimmers (age: 14.99 ± 0.13 years old; height: 1.71 ± 0.02 m; body mass: 61.28 ± 1.27 kg; Fédération Internationale de Natation [FINA] points: 651.59 ± 6.44) and 17 non-elite swimmers (age: 14.65 ± 0.19 years old; height: 165.12 ± 2.03 cm; body mass: 57.22 ± 2.43 kg; FINA points: 405.71 ± 21.41) volunteered to participate in this cross-sectional study. Individual-test FMS® scores, FMS® composite score and FINA points were considered for analysis. Elite swimmers achieved higher Deep Squat (p = 0.005; ES = 0.99), Right Hurdle Step (p = 0.005; ES = 0.99), Left Hurdle Step (p = 0.002; ES = 1.08), Trunk Stability Push Up ($p < 0.001$; ES = 1.44) and FMS® composite ($p < 0.001$; ES = 1.35) scores compared to non-elite swimmers. FMS® composite scores were positively related with 100m freestyle performance (r = 0.596, r^2 = 40.9%, $p < 0.001$). Young non-elite swimmers reveal functional deficits in tasks involving mobility of the hips, knees and ankles, and stabilization of the core and spine. Higher movement functionality is positively related with 100m freestyle performance. Swimming coaches should consider these deficits and their relationship with performance to differentiate exercise prescription between this populations.

Keywords: Swimming Performance; Functional Performance; Competitive Swimmers; Movement Screen; Young Swimmers.

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RESUMEN

O *Functional Movement Screen*® (FMS®) permite avaliar a funcionalidade do movimento em atletas. A funcionalidade do movimento em jovens nadadores de elite e não-elite pode prever o desempenho futuro. O objetivo deste estudo é comparar os *scores* do FMS® entre jovens nadadores de elite e não-elite e verificar sua relação com o desempenho de 100m no estilo livre. Trinta e dois nadadores de elite (idade: 14,99 ± 0,13 anos; altura: 1,71 ± 0,02 m; massa corporal: 61,28 ± 1,27 kg; Fédération Internationale de Natation [FINA] pontos: 651,59 ± 6,44) e 17 nadadores não-elite (idade: 14,65 ± 0,19 anos; altura: 165,12 ± 2,03 cm; massa corporal: 57,22 ± 2,43 kg; pontos FINA: 405,71 ± 21,41) que se voluntariaram para participar neste estudo transversal. *Scores* FMS® de teste individual, *scores* compostos FMS® e pontos FINA foram considerados para análise. Nadadores de elite alcançaram valores mais elevados no *Deep Squat* (p = 0,005; ES = 0,99), *Right Hurdle Step* (p = 0,005; ES = 0,99), *Left Hurdle Step* (p = 0,002; ES = 1,08), *Trunk Stability Push Up* (p < 0,001); ES = 1,44) e FMS® compostos (p < 0,001; ES = 1,35) em comparação com nadadores não elite. Os *scores* compostos do FMS® foram positivamente relacionados com o desempenho de 100m no estilo livre ($r = 0,596$, $r^2 = 40,9\%$, $p < 0,001$). Jovens nadadores do grupo não-elite revelam défices funcionais em tarefas que envolvem mobilidade das ancas, joelhos e tornozelos e estabilização do núcleo e da coluna. A maior funcionalidade de movimento está positivamente relacionada ao desempenho de 100m estilo livre. Os treinadores de natação devem considerar esses défices e sua relação com o desempenho para diferenciar a prescrição de exercícios entre essas populações.

Palabras clave: Rendimiento de natación; Rendimiento funcional; Nadadores competitivos; Pantalla de movimiento; Jóvenes nadadores.

RESUMO

O *Functional Movement Screen*® (FMS®) permite avaliar a funcionalidade do movimento em atletas. A funcionalidade do movimento em jovens nadadores de elite e não-elite pode prever o desempenho futuro. O objetivo deste estudo é comparar os *scores* do FMS® entre jovens nadadores de elite e não-elite e verificar sua relação com o desempenho de 100m no estilo livre. Trinta e dois nadadores de elite (idade: 14,99 ± 0,13 anos; altura: 1,71 ± 0,02 m; massa corporal: 61,28 ± 1,27 kg; Fédération Internationale de Natation [FINA] pontos: 651,59 ± 6,44) e 17 nadadores não-elite (idade: 14,65 ± 0,19 anos; altura: 165,12 ± 2,03 cm; massa corporal: 57,22 ± 2,43 kg; pontos FINA: 405,71 ± 21,41) que se voluntariaram para participar neste estudo transversal. *Scores* FMS® de teste individual, *scores* compostos FMS® e pontos FINA foram considerados para análise. Nadadores de elite alcançaram valores mais elevados no *Deep Squat* (p = 0,005; ES = 0,99), *Right Hurdle Step* (p = 0,005; ES = 0,99), *Left Hurdle Step* (p = 0,002; ES = 1,08), *Trunk Stability Push Up* (p < 0,001); ES = 1,44) e FMS® compostos (p < 0,001; ES = 1,35) em comparação com nadadores não elite. Os *scores* compostos do FMS® foram positivamente relacionados com o desempenho de 100m no estilo livre ($r = 0,596$, $r^2 = 40,9\%$, $p < 0,001$). Jovens nadadores do grupo não-elite revelam défices funcionais em tarefas que envolvem mobilidade das ancas, joelhos e tornozelos e estabilização do núcleo e da coluna. A maior funcionalidade de movimento está positivamente relacionada ao desempenho de 100m estilo livre. Os treinadores de natação devem considerar esses défices e sua relação com o desempenho para diferenciar a prescrição de exercícios entre essas populações.

Palavras-chave: Desempenho na Natação; Performance funcional; Nadadores competitivos; Rastreio de movimento; Nadadores jovens.

INTRODUCTION

Functional Movement Screen® (FMS®) test battery has been proposed as a reliable instrument to assess athletes' functional movement patterns in daily sports practice (Kraus et al, 2014; Grible et al, 2013, Onate et al., 2012; Teyhen et al., 2012, Minick et al., 2010). Moreover, despite controversial evidence (Mokka, Sprague, & Gatens, 2016), FMS® composite scores under 14 points have been suggested as a cut-off point to predict musculoskeletal injury risk among athletes (Chorba et al., 2010; Kiesel, Plisky, & Voight, 2007; O`Connor et al., 2011). FMS® comprises 7 fundamental movement patterns that require mobility, neuromuscular control, balance, and stability. To evaluate movement functionality, athletes are assessed on a scale from 0 to 3, in which 0 denotes experienced pain and 3 indicates that the movement was completed without any compensation (Cook et al., 2014a). The highest total score that can be attained on the FMS® is twenty-one points(Cook et al., 2014b). Even though the FMS® test battery has been used by sports professionals to assess functional movement patterns in several sports (Anderson, Nrumann, & Bliven, 2015, Marques et al., 2017; Kuzuhara, et al, 2018; Kiesel, Plisky, & Butler, 2011; Nicolazakes et al., 2017), only a few applied it to swimmers (Bond et al., 2015; Gunay, et al., 2017, Bullock et al, 2017).

Swimming is a sport that involves closed and continuous motor skills (Duarte-Mendes et al, 2019) and the performance can be influenced by several factors such as physiological, biomechanical, and anthropometric characteristics (Okada, Huxel, & Nesser, 2011). The relationship between physical characteristics and sprint swimming performance in young swimmers has been studied (Connaboy, et al., 2015; Geladas, Nassis, & Pavlicevics, 2005; Garrido et al, 2012). Ankle, knees, hip, and shoulder mobility have been referred to as key kinematic determinants of undulatory underwater swimming at maximal velocity (Connaboy, et al., 2015). Interestingly, ankle and shoulder mobility were not related to swimming performance in male swimmers, whereas shoulder mobility was significantly related to 100m freestyle performance in female swimmers (Geladas, Nassis, & Pavlicevics, 2005). To aid scientific research on this topic, the relationship between FMS® scores and young swimmers' performance has been analyzed (Bond et al., 2015; Gunay, et al., 2017). Despite the few studies, higher FMS® composite scores have been positively related to 100m freestyle performance in youth swimmers (Bond et al., 2015), while 200m individual medley performance does not seem to be related to FMS® composite scores in youth swimmers (Gunay, et al., 2017). However, given that in freestyle races any swimming stroke may be used (FINA rules, 2017), this technique may be more representative of swimmers' functional movement patterns. Further, the 100m freestyle long course event is the key distance in competitive swimming and has been on every Olympic program since 1904 (men) and 1912 (women) (Post et al., 2020).

To the best of our knowledge, there are no studies comparing FMS® scores in elite and non-elite swimmers, specifically at young ages (under eighteen years old). In fact, swimming performance from a young age is highly valued and considered as a strong predictor of success (KNZB, 2020). Assessing the physical skills of young swimmers is important for coaches, sports professionals and swimmers (Bond et al., 2015). This knowledge could be relevant for swimming coaches, being able to effectively manage young elite and non-elite swimmers' movement functionality according to their specific needs, maximizing performance. Thus, the aim of the current study was to assess and compare FMS® scores between young elite and non-elite swimmers, as well as to verify their relationship with 100m freestyle performance. It was hypothesized that elite swimmers would have higher FMS® scores compared to non-elite swimmers. A secondary hypothesis was that FMS® composite scores would be positively correlated to 100m freestyle performance.

MATERIAL Y MÉTODOS

Participants

In this quantitative study with a cross-sectional design, thirty-two elite swimmers (age: 14.99 ± 0.13 years old; height: 1.71 ± 0.02 m; body mass: 61.28 ± 1.27 kg; Fédération Internationale de Natation [FINA] points: 651.59 ± 6.44) and 17 non-elite swimmers (age: 14.65 ± 0.19 years old; height: 165.12 ± 2.03 cm; body mass: 57.22 ± 2.43 kg; FINA points: 405.71 ± 21.41) volunteered to participate in this cross-sectional study. Elite swimmers were considered those who were members of the Portuguese National Swimming Team and non-elite swimmers were considered those who competed at a national level. All subjects were free of any functional limitation that would preclude them to perform the experimental protocol and had at least one year of experience in swimming competitions. Subjects were excluded if they reported any musculoskeletal injury in the last year. All subjects and their parents were informed beforehand about the benefits, risks, purposes, and procedures of the study and gave their written consent. The current study was conducted according to the Declaration of Helsinki and the protocol was fully approved by the Institutional research ethics committee of the University of Beira Interior (CE-UBI-Pj-2018-051:M7247).

Structured protocol and data collection

The evaluation was conducted on two different days, one for each group. Before the FMS® assessment, each subject's age, height, and body mass were collected. FINA points were calculated after inquiring the participants' coach about each athlete's 100m freestyle best swim time. All subjects performed the 7-test battery FMS®, receiving standardized verbal instructions.

Measures

Functional Movement Screen®

FMS® comprises 7 tests performed in the following order: Deep Squat (assessing hips, knees and ankles mobility), Hurdle Step (assessing proper stride mechanics during a stepping motion), Inline Lunge (assessing hip and ankle mobility and stability, quadriceps flexibility, and knee stability), Shoulder Mobility (assessing bilateral and reciprocal shoulder range of motion, scapular mobility, and thoracic spine extension), Active Straight Leg Raise (assessing active hamstring and gastro-soleus flexibility while maintaining a stable pelvis and core), Trunk Stability Push Up (assessing stabilization of the core and spine in an anterior and posterior plane during a closed-chain upper body movement) and Rotary Stability (assessing neuromuscular coordination and energy transfer from one segment of the body to another through the torso) (Cook et al., 2014a,b). Athletes were assessed by two experienced raters using the FMS® test battery. The 7 tests were assessed on a scale of 0 to 3 according to the following criteria: 0 - experienced pain during the testing; 1 - unable to complete the movement pattern or unable to assume the position to perform the movement; 2 - able to complete the movement with compensations; 3 - performs the movement correctly without any compensation, complying with standard movement expectations associated with each test (Cook et al., 2014b). Except for the Deep Squat and Trunk Stability Push Up tests, each side of the body was assessed unilaterally, considering only the side with the lowest score. Subjects performed three trials of each movement, and the highest score was considered for analysis (Cook et al., 2014a). After the test battery was performed, both raters verified agreement of the given scores for each test. If there was disagreement in any scored test, the subject was asked to repeat the given movement. Composite scores were calculated by summing each individual-test score (Cook et al., 2014a).

Measures of Swimming Performance

Swimming performance was assessed using the FINA points system which allows comparisons of performances regardless of technique or distance swam (FINA, 2011). To that end, the participant's coach provided information regarding each athlete's 100m freestyle personal best swim time. Then, each time was converted to FINA points, a standard measure of international swimming performance where 1000 points represents the average of the top 10 all-time results in each event.

Statistical analysis

Descriptive statistics (mean ± standard deviation) were performed for age, height, bodyweight, FINA points, FMS® individual-test scores, and FMS® composite scores. Data normality was tested using the Kolmogorov-Smirnov and Shapiro-Wilk tests for the elite and non-elite groups, respectively. Therefore, FMS® composite scores ($p = 0.19$ vs. $p = 0.652$ for the elite and non-elite group, respectively) were analyzed using a Student's T-test, whereas FMS® individual-test scores ($p < 0.05$ for all tests) were analyzed using a Mann-Whitney U test. When analyzing the overall sample, a Kolmogorov Smirnov test was used to test for distribution normality of FMS® composite score and FINA points variables ($p = 0.012$ vs $p = 0.000$, respectively). Spearman's rank correlation coefficient

(r) and coefficient of determination (r^2) were used to verify correlations between FINA points and FMS® composite scores. The strength of the relationship was classified as follows (Mukaka, 2012): very high ($0.90 < r < 1.00$); high ($0.70 < r < 0.90$); moderate ($0.50 < r < 0.70$); low ($0.30 < r < 0.50$); little ($0.10 < r < 0.30$). Furthermore, the magnitude of effects was classified as follows (Lakens, 2013): small (ES = 0.2); moderate (ES = 0.5); large (ES = 0.8). The statistical analysis was performed using SPSS software (IBM Corp. Released in 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) and the significance level was set at $p < 0.05$.

RESULTADOS

The subject's anthropometric characteristics and FINA points are displayed in Table I.

Table I. Anthropometric characteristics and FINA points of young elite and non-elite swimmers.

	Elite Group (n = 32)	Non-elite Group (n = 17)
Age (years old)	14.99 ± 0.13	14.65 ± 0.19
Height (cm)	171.25 ± 1.49	165.12 ± 2.03
Bodyweight (kg)	61.28 ± 1.27	57.22 ± 2.43
FINA points	651.59 ± 6.44	405.71 ± 21.41

Table note: Data are expressed as mean ± standard deviation (SD)

Table II presents the values of FMS® individual-test scores and FMS® composite scores, as well as differences between group analysis. Differences were found between elite and non-elite groups on the Deep Squat (p = 0.005; ES = 0.99, large effect), Right Hurdle Step (p = 0.005; ES = 0.99, large effect), Left Hurdle Step (p = 0.002; ES = 1.08, large effect) and Trunk Push Up ($p < 0.001$; ES = 1.4, large effect) tests. Although there were no statistically significant differences between groups on the Left Rotary Stability, the effect size indicates a moderate effect (p = 0.114; ES = 0.52). The elite group achieved higher scores for all tests, except for the Left Shoulder Mobility. However, no statistical differences were found in the aforementioned test (p = 0.472; ES = 0.2). The elite group FMS® composite scores were significantly higher ($p < 0.001$; ES = 1.35, large effect) compared to the non-elite group.

There was a positive and moderate relationship (r = 0.596, r^2 = 40.9%, $p < 0.001$) between FMS® composite scores and 100m freestyle performance (FINA points) (Figure 1).

DISCUSIÓN

The purpose of the current study was to assess and compare FMS® scores in young elite and non-elite swimmers and to verify their relationship with 100m freestyle performance. The main findings of the present study were: (i) young elite swimmers achieved significantly higher Deep Squat, Left Hurdle Step, Right Hurdle Step, Trunk Stability Push Up and FMS® composite scores compared to young non-elite swimmers; (ii) FMS® composite scores were positively correlated with 100m freestyle performance.

FMS® has been used to assess functional movement patterns in several sports (Anderson, Nrumann, & Bliven, 2015, Marques et al., 2017; Kuzuhara, et al, 2018; Kiesel, Plisky, & Butler, 2011; Nicolazakes et al., 2017). However, only a few applied FMS® to swimmers (Bond et al., 2015; Gunay, et al., 2017, Bullock et al, 2017) and no studies have compared FMS® scores between young elite and non-elite swimmers.

Table II. Descriptive statistics (mean ± SD) of FMS® individual-test, FMS® composite score, and differences between group analysis.

	Elite group (n = 32)	Non-Elite group (n = 17)	*p*	ES
Deep Squat	2.53 ± 0.51	2.00 ± 0.61	0.005[a]*	0.99
Right Hurdle Step	2.53 ± 0.51	2.00 ± 0.61	0.005[a]*	0.99
Left Hurdle Step	2.34 ± 0.55	1.76 ± 0.56	0.002[a]*	1.08
Right Inline Lunge	2.53 ± 0.57	2.35 ± 0.70	0.413[a]	0.30
Left Inline Lunge	2.53 ± 0.58	2.29 ± 0.69	0.237[a]	0.40
Right Shoulder Mobility	2.56 ± 0.62	2.47 ± 0.72	0.714[a]	0.14
Left Shoulder Mobility	2.53 ± 0.62	2.65 ± 0.61	0.472[a]	0.20
Right Active Straight Leg Raise	2.53 ± 0.62	2.29 ± 0.59	0.149[a]	0.40
Left Active Straight Leg Raise	2.41 ± 0.62	2.18 ± 0.53	0.159[a]	0.40
Trunk Stability Push Up	2.81 ± 0.39	2.18 ± 0.53	0.000[a]*	1.44
Right Rotary Stability	2.28 ± 0.46	2.06 ± 0.56	0.170[a]	0.46
Left Rotary Stability	2.28 ± 0.52	2.00 ± 0.61	0.114[a]	0.52
Composite Score	17.03 ± 1.81	14.59 ± 1.94	0.000[b]*	1.35

Table note: *p < 0.01

[a,b]A Mann-Whitney U test[a] or Student's T test[b] were used according to normality distribution.

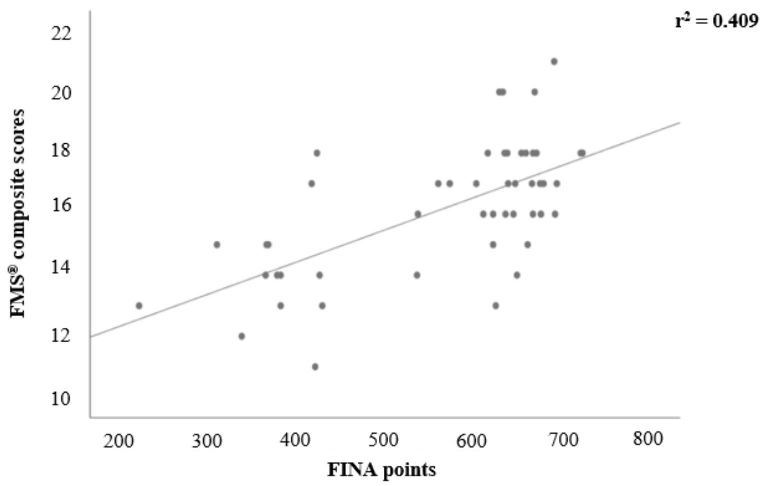

Figure 1. Correlation between FMS® composite scores and FINA points (r = 0.596, *p* < 0.001).

In the present study, the elite group achieved significantly higher Deep Squat, Left Hurdle Step, Right Hurdle Step, Trunk Stability Push Up and FMS® composite scores than the non-elite group. These results suggest that young non-elite swimmers may have relevant functional deficits in tasks involving mobility of the hips, knees and ankles (Deep Squat test), proper stride mechanics during a stepping motion (Hurdle Step test), and also stabilization of the core and spine in an anterior and posterior plane during a closed-chain upper body movement (Trunk Stability Push Up test). Future studies aiming to identify or differentiate movement functionality deficits in young elite and non-elite swimmers are needed. This would allow swimming coaches to provide training programs according to swimmers' specific needs in an early stage of their careers, which has been suggested to predict future competitive success (Post et al., 2020).

Interestingly, even though we have not found significant differences between young elite and non-elite swimmers in the Shoulder Mobility test, the non-elite group achieved higher scores on Left Shoulder Mobility test. The Shoulder Mobility test assesses bilateral and reciprocal shoulder range of motion, combining internal rotation with adduction of one shoulder and external rotation with the abduction of the other. The test also requires normal scapular mobility and thoracic spine extension (Cook et al., 2014b). It is widely agreed that swimming injuries are overuse in nature (Hill, Collins, & Posthumus, 2015; Kerr et al., 2013) and highly frequent in shoulders during an athlete's career (Barbosa et al, 2000; Blache, 2018). Despite the higher scores on the Left Shoulder Mobility test, the non-elite group revealed higher asymmetry incidence when compared to the elite group. That might be due to the breathing technique used during freestyle swimming if there is a lateral dominance that may lead to incorrect swimming technique and increase those imbalances (Higson, 2018). Therefore, more research is needed to clarify the potential influence of swimming techniques on movement functionality asymmetries which may predispose swimmers to overuse injury.

There is limited data regarding the relationship between FMS® scores and physical performance among athletes (Kraus, 2014; Silva et al., 2015). In fact, a thorough search of the relevant literature yielded only two studies analyzing the relationship between FMS® composite scores and swimming performance (Bond, 2015; Gunay, 2017). When analyzing the referred relationship, we found a positive correlation between FMS® composite scores and 100m freestyle performance, i.e., young swimmers with higher levels of movement functionality were able to achieve better performances. These results supported previous research where 100m freestyle performance was also positively related to movement functionality in young swimmers (Bond, 2015). In another study, the authors analyzed the relationship between FMS® composite scores and 200m individual medley swimming performance (Gunay, 2017). Although they did not find a correlation between the aforementioned variables, it should be noted that the distance and swimming stroke analyzed were not the same as ours. Since FMS® comprises 7 fundamental movement patterns that require mobility, neuromuscular control, balance, and stability, our results also support previous research that referred to ankle, knees, hip and shoulder mobility as key kinematic determinants of sprint swimming performance (Connaboy, 2015). Interestingly, ankle and shoulder mobility have not been related to swimming performance in male swimmers, whereas shoulder mobility was significantly related to 100m freestyle performance in female swimmers (Geladas, Nassis, & Pavlicevics, 2015). However, these authors did not use FMS® test battery and thus more research is needed to clarify the relationship between swimmers' functional movement patterns assessed through FMS® and 100m freestyle performance.

There are some limitations that we should be aware in the current study. First, we should mention the sample's dimension and heterogeneity (elite group n = 32; non-elite group n = 17). Secondly, we have considered neither the athlete's history of injuries nor the training frequency. Past injuries and training frequency should be considered since those variables potentially impact on swimming performance (Okada, Huxel, & Nesser, 2011). Our sample consisted of only young swimmers and we should be careful when generalizing our findings for older trained swimmers. All variables were assessed at one moment (cross-sectional design) (Cid et al., 2019; Monteiro et al., 2018, Rodrigues et al., 2019). Finally, we have not analysed analyzed relevant variables such as anthropometric data (e.g.: skinfolds, body fat percentage, waist-to-hip ratio). By including anthropometric data, we could have been able to draw more accurate comparisons with previous studies. Further research including longitudinal and experimental investigation on functional movement development and physical performance in young swimmers is needed.

CONCLUSIONES

Our findings have shown that young elite swimmers have higher movement functionality compared to young non-elite swimmers. In fact, young non-elite swimmers might have relevant functional deficits in tasks involving mobility of the hips, knees and ankles, proper stride mechanics during a stepping motion, and also stabilization of the core and spine in an anterior and posterior plane during a closed-chain upper body movement. Furthermore, our results suggest that young swimmers with higher movement functionality are able to achieve better performances in 100m freestyle.

PRACTICAL IMPLICATIONS

Swimming coaches/medical staff should be aware of the potential movement functionality differences between young elite and non-elite swimmers since specific deficits require adjusted training programs in order to maximize performance.

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