How to Improve Motor Learning: The Effects of Attentional Focus Strategies on Adolescent Performance

Come migliorare l'apprendimento motorio: Effetti delle strategie di focalizzazione attentiva sulla performance negli adolescenti

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DOUBLE BLIND PEER REVIEW

ABSTRACT

The effectiveness of instructional strategies in youth athletic training is a central topic in sports psychology. This is because the strategies used can influence cognitive parameters as well as performance outcomes. This study aimed to investigate the effects of different attentional focus strategies (internal focus vs external focus) on neuromuscular performance outcomes and their short- and medium-term retention in adolescent athletes. Two specific strategies were used: one based on external focus, directing the young athletes' cognition towards the visible effects of movement, and one based on internal focus, centring their attention on the biomechanical mechanisms underlying the manifest movement. The exercise protocols adopted are based on the Sincrony movement methodology, ensuring a coordinated execution adapted to the principles of motor control. A sample of 196 adolescents (15.25 ± 0.75 years old) was divided into two groups, both working for eight weeks with identical physical exercises but different focus instructions. All participants, after a familiarisation period, were tested before and after the intervention, as well as in a four-week follow-up after the end of the intervention. They were assessed using force platform jump tests and a maximal strength test for the upper limbs with electronic dynamometers. The results showed significant improvements in jump height, jump power, and maximal strength ($p < 0.001$) in both groups. However, the internal focus group exhibited greater stability over time, particularly in maximal strength, whereas the external focus group achieved more immediate improvements in explosive performance, with a similar performance decline between the groups in jump tests at follow-up.

L'efficacia delle strategie di istruzione nell'allenamento sportivo giovanile rappresenta un tema centrale nella psicologia dello sport, poiché le modalità di insegnamento possono influenzare sia i parametri cognitivi sia gli esiti prestazionali. Il presente studio indagato gli effetti di diverse strategie di focalizzazione attentiva (focus interno vs focus esterno) sugli esiti della prestazione neuromuscolare e sulla loro ritenzione a breve e medio termine in atleti adolescenti. Sono state utilizzate due strategie specifiche: una basata sul focus esterno, che orienta i processi cognitivi dei giovani atleti verso gli effetti visibili del movimento, e una basata sul focus interno, che concentra l'attenzione sui meccanismi biomeccanici sottesi al movimento manifesto. I protocolli di esercizio adottati si basano sulla metodologia di movimento Sincrony, garantendo un'esecuzione coordinata conforme ai principi del controllo motorio. Un campione di 196 adolescenti (15,25 ± 0,75 anni) è stato suddiviso in due gruppi, entrambi impegnati per otto settimane in esercizi fisici identici ma con istruzioni attenzionali differenti. Tutti i partecipanti, dopo un periodo di familiarizzazione, sono stati valutati prima e dopo l'intervento, nonché in un follow-up a quattro settimane dalla conclusione del protocollo. Le valutazioni sono state effettuate mediante test di salto su pedana di forza e tramite un test di forza massimale degli arti superiori con dinamometri elettronici. I risultati hanno evidenziato miglioramenti significativi nell'altezza di salto, nella potenza del salto e nella forza massimale ($p < 0,001$) in entrambi i gruppi. Tuttavia, il gruppo con focus interno ha mostrato una maggiore stabilità nel tempo, in particolare nella forza massimale, mentre il gruppo con focus esterno ha ottenuto miglioramenti più immediati nelle prestazioni esplosive, con un declino delle prestazioni nei test di salto al follow-up simile tra i due gruppi.

KEYWORDS
Attentional focus, Motor learning, Instructional strategies, Cognitive and performance outcomes, Adolescents
Focalizzazione attentiva, Apprendimento motorio, Strategie di istruzione, Esiti cognitivi e prestativi, Adolescenti

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1. Introduction

The selection of appropriate and specific instructional strategies is a crucial factor in enhancing athletic performance, especially among adolescent athletes (Pestano, 2021; Platvoet et al., 2018; Tolentino, 2020). A primary aspect in this regard concerns the way instructions are formulated for the execution of motor actions by coaches and trainers (LaPlaca & McCullick, 2018; Cronin et al., 2000). Two key instructional strategies have been analysed:

- External focus, which emphasises observable effects of movement, providing descriptive guidance and corrective feedback based on visible outcomes.
- Internal focus, which directs attention towards the biomechanical mechanisms underlying movement generation, even when not immediately visible (Hunt et al., 2017; Wulf & Prinz, 1998).

These approaches are applied in exercises requiring both strength and technical coordination, such as bench press training and vertical jump exercises. In the context of vertical jumps, external focus suggests movement execution through result-oriented instructions, such as "Try to jump as high as possible". Corrections are based on observable factors, such as monitoring foot positioning before and after the jump to provide corrective feedback like: "You landed forward; try to land in the same spot, avoiding horizontal displacement" (Porter et al., 2010; Ducharme et al., 2016). This approach has proven effective in enhancing immediate performance, particularly in movements that are not yet well-established, as it facilitates motor control processes (Wulf & Lewthwaite, 2016). Conversely, an internal focus directs the athlete's attention towards the biomechanical causes of the movement, emphasising control over individual body segments. In the case of vertical jumps, the instruction might be "Push forcefully downwards" to maximise the efficiency of propulsion (Schmidt & Lee, 2011; Bobbert & Van Soest, 1994). However, while external focus promotes more automatic execution, internal focus can demand greater cognitive engagement, making it less effective in immediate performance but potentially more advantageous for long-term skill retention, fostering more stable motor learning (Marchant, 2011; Wulf, 2013). Further studies, such as those by McNevin and Wulf (2002) and Yao et al. (2020), have shown that focusing on visible effects of movement can enhance immediate motor performance and be particularly beneficial for explosive strength training. These results have been confirmed in static exercises, such as bench press training (Chen, 2005). In contrast, using an internal focus, where understanding the causes of movement is fundamental, appears to improve technical execution and strength development, even in more complex exercises (Batista et al., 2018). Recent studies in youth populations have demonstrated that adopting targeted instructional strategies, such as clear instructions and differentiated corrective feedback, can influence motor performance in young athletes. For example, Bortoli and Robazza (2016) highlighted how the type of coaching instruction can either facilitate or hinder the learning and refinement of motor skills. Specifically, a study conducted by Porter et al. (2010) found that external focus instructions, such as "Touch a high point during the jump", can increase jump height compared to internal focus instructions. On the other hand, Marchant et al. (2009) observed that an internal focus is associated with improved motor control and learning within the same population. An important methodology that examines the differences between cause-based and effect-based movement instruction is the Synchrony Methodology (2008), which has demonstrated significant differences between these instructional approaches (De Bernardi, 2008; Fogliata et al., 2024). Determining which type of instruction and correction is most advantageous for improving prelearned movements and long-term athletic performance could be particularly valuable for optimising sports learning in young athletes (Juntara, 2019; Tolentino, 2020). A proper selection of instructional strategies could improve teaching effectiveness by helping coaches provide appropriate guidance aligned with the specific objectives of a given motor exercise (Pan et al., 2022). Additionally, since adolescence is a sensitive period for the development of physical and technical abilities, the adoption of suitable instructional strategies could be crucial in ensuring the long-term consolidation of motor learning (Malina et al., 2004).

2. Materials and Methods

The study was conducted on a sample of 196 adolescents (mean age: 15.25 ± 0.75 years; mean height: 168.4 ± 7.2 cm; mean weight: 60.1 ± 5.35 kg; BMI: 21.15 ± 1.75 kg/m^2), recruited from local schools and sports associations. The selection of participants followed strict criteria to ensure sample homogeneity within the adolescent age range, a phase characterised by significant physiological and motor changes, as well as gender differences (Malina et al., 2004). The inclusion criteria applied were as follows:

- Participants had a minimum training age of six months and were involved in organised sports activities with a frequency of three or more sessions per week. On average, participants had a training age of approximately 3.5 years. No participants were completely sedentary (World Health Organization, 2020).
- No recent injuries, defined as no lower or upper limb injuries in the six months preceding the study, a necessary condition to prevent bias from functional limitations (Bahr, 2003).
- Absence of disabling conditions, such as cardiovascular, respiratory, or orthopaedic diseases, to eliminate interference in results due to pre-existing physical limitations (Smith & Biddle, 2008).
- Normal Body Mass Index (BMI), according to the World Health Organization guidelines for paediatric age, to minimise the influence of metabolic factors on physical and motor performance (WHO, 2020).
- Willingness to participate for the entire duration of the study, including eight weeks of intervention followed by a twelve-week follow-up to assess long-term effects, with at least 90% attendance in training sessions.

The sample consisted of 98 males (50%) and 98 females (50%), equally distributed between the external focus group and the internal focus group (Lin et al., 2018). Participants were divided into two groups based on demographic and anthropometric characteristics, following stratified block randomisation (Trapero-Asenjo et al., 2025), using a 1:1 ratio between Group 1 with External Focus (EF) and Group 2 with Internal Focus (IF). Stratification was performed for categorical variables (males: 98, 50%; females: 98, 50%) and continuous variables (age, height, weight, and BMI) (see Table 1). Additionally, independent sample t-tests were conducted for continuous variables, while the chi-square test was used for categorical variables (gender). The results showed no statistically significant differences between the groups ($p > 0.05$ for all variables), confirming group homogeneity (Sheehan et al., 2024).

Variable	Group 1 Fe (n = 98)	Group 2 Fi (n = 98)
Age (years)	15.3 ± 0.8	15.2 ± 0.7
Height (cm)	168.5 ± 7.1	168.2 ± 7.3
Weight (kg)	60.3 ± 5.5	60.0 ± 5.2
BMI (kg/m²)	21.2 ± 1.8	21.1 ± 1.7

Table 1. Participant Groups characteristics

All participants from both groups were assessed on vertical jump performance and dumbbell bench press extension. For the evaluation of vertical jump capacity, the ChronoJump Bosco System force platform was used to measure jump height and power (Bosco et al., 1979; Perez-Castilla et al., 2019). Participants from both groups performed five maximal jumps for each jump type in three separate assessment sessions (T0-T1-T2). The test sequence was randomised and conducted in the same experimental environment. Additionally, heart rate monitoring was carried out using a Polar H10 heart rate monitor (Polar Electro Oy, Finland) to ensure that each athlete performed the tests under comparable physiological conditions across trials. Each jump was separated by a 90-second recovery period, in line with the guidelines for explosive power assessment (Cormie et al., 2009). The jump types were divided into two categories:

- Squat Jump (SJ): Participants positioned themselves on the force platform with knees flexed at approximately 90°, keeping the trunk upright and hands placed on the hips to prevent arm usage. After an auditory signal, they performed a maximal vertical jump from a static position, without any countermovement.
- Countermovement Jump (CMJ): Participants began in a standing position, feet aligned with shoulder width, and hands on the hips. Upon the auditory signal, they executed a rapid downward movement, immediately followed by a maximal jump, utilising the stretch-shortening cycle (SSC) of the muscles.

Additionally, all participants were assessed in the bench press exercise, using the DS2 digital dynamometer, which is integrated into the dynamometric dumbbells, ensuring a precision of ±0.2% of the full scale (Schoenfeld et al., 2016). The peak intensity of maximal force exerted during the exercise was evaluated (Weakley et al., 2020). One month before the start of the study, all participants underwent a familiarisation period with the tests. The measurements were then conducted at three distinct time points:

- T0 (Baseline): The week prior to the start of the intervention.
- T1 (Post-Intervention): At the end of the 8-week experimental phase.
- T2 (Follow-Up): Twelve weeks after T1.

During the experimental phase, all participants followed an enhanced physical training programme within their regular training hours, standardised and lasting 8 weeks. Both groups completed two training sessions per week with the same coaching and medical staff. The only variation between Group 1 (EF) and Group 2 (IF) within each session was the type of instructional guidance provided by the staff during the same exercises. Each specific training session lasted 60 minutes, prior to the technical training session, and was structured into three distinct phases: warm-up (10 minutes); main training phase (40 minutes) (see Table 2) and Cool-down (10 minutes).

Weeks	*Exercise*	*Sets*	*Reps/Time*	*Intensity/Details*
1-2	SJ and lunges	3	10 reps	Bodyweight
1-2	CMJ and calf	3	8 reps	Bodyweight
1-2	Plyometry	3	6 reps	From a 40 cm platform
1-2	Bench Press	3	10 reps	70% 1RM
1-2	Plank and Crunch	3	30 sec	Bodyweight
3-4	SJ and lunges	3	12 reps	Bodyweight
3-4	CMJ and calf	3	10 reps	Bodyweight
3-4	Plyometry	3	8 reps	From a 40 cm platform
3-4	Bench Press	3	12 reps	75% 1RM
3-4	Plank and Crunch	3	45 sec	Bodyweight
5-6	SJ and lunges	4	10 reps	Bodyweight
5-6	CMJ and calf	4	8 reps	Bodyweight
5-6	Plyometry	4	6 reps	From a 40 cm platform
5-6	Bench Press	4	10 reps	80% 1RM
5-6	Plank and Crunch	4	30 sec	Bodyweight
7-8	SJ and lunges	4	12 reps	Bodyweight
7-8	CMJ and calf	4	10 reps	Bodyweight
7-8	Plyometry	4	8 reps	From a 40 cm platform
7-8	Bench Press	4	12 reps	85% 1RM
7-8	Plank and Crunch	4	45 sec	Bodyweight

Table 2. Main training phase

In Group 1 (EF), the instructions provided to participants were based on perceiving the visible effects of movement, emphasising the final goal of the action rather than the biomechanical mechanisms involved. For example, in the vertical jump, the instructions given were: "Jump as high as possible", encouraging athletes to focus on the outcome of the movement rather than on the execution details. Similarly, in the bench press exercise, participants received instructions such as "Push the dumbbells upwards to full extension", aiming to direct attention towards the trajectory and final result of the movement. The technical corrections provided by the coaching staff were also based on external observation of the motor action, with feedback focused on improving movement consistency without directly intervening in the internal motor control mechanisms. In Group 2 (IF), on the other hand, the instructions emphasised the internal biomechanical aspects of movement, guiding participants' attention towards muscular forces and body segments involved in the execution of the exercise. For the vertical jump, instructions included prompts such as "Push forcefully downwards", encouraging greater activation of the lower limb extensor chain. In the bench press exercise, the focus was instead on correct muscle activation, with instructions like "Push the bench with your shoulders", aimed at optimising scapular stability and muscle recruitment. In this case as well, the corrections provided by the coaching staff aligned with the adopted approach, intervening directly in the biomechanics of movement and correcting inefficiencies in the kinetic chain. The number and frequency of verbal instructions and feedback were standardised across experimental conditions. Both groups received the same amount of instructional input per session; the only difference concerned the content of the attentional focus (external vs internal).

2.1 Ethical considerations

This study was conducted in compliance with ethical guidelines for research involving human participants, in accordance with the Declaration of Helsinki (2013) and the regulations set by the Italian National Olympic Committee (CONI) on sports and psychological research ethics. All participants and their legal guardians received detailed information regarding the purpose, procedures, benefits, and potential risks of the study. Written informed consent was obtained from parents or legal guardians, as the participants were minors. The personal data collected were handled in compliance with privacy regulations (GDPR 2016/679), ensuring anonymity and data protection. Furthermore, this study was conducted in compliance with regulations under protocol number seinfo-VS-2022-045.

3. Data analysis

Data analyses were conducted using IBM SPSS Statistics 20. A normality test was performed for each parameter (jump height, jump power, and maximal bench press strength). Using the Shapiro-Wilk test, the variables measured at T0, T1, and T2 exhibited a normal distribution in both groups ($p > 0.05$). Sphericity was assessed using Mauchly's test. For variables where no sphericity violation was detected ($p > 0.05$), ANOVA was applied without correction. In cases where sphericity was violated (jump height), the Greenhouse-Geisser correction was used. A 3 × 2 repeated-measures ANOVA was conducted, with Time (T0, T1, T2) as the within-subject factor and Group (EF, IF) as the between-subject factor. Additionally, eta squared (η^2) effect sizes were calculated, and pairwise comparisons were conducted using the Bonferroni correction (see Table 3). To assess the magnitude of the ANOVA effect, eta squared (η^2) values were calculated. The results showed a significant effect of time for all variables analysed: Jump height: $\eta^2 = 0.310$, Jump power: $\eta^2 = 0.280$, Maximal strength: $\eta^2 = 0.367$. The effect of the group was small to moderate (η^2 between 0.040 and 0.065), whereas the Time × Group interaction showed a moderate effect for jump height ($\eta^2 = 0.060$) and jump power ($\eta^2 = 0.070$), with a significant effect on maximal strength ($\eta^2 = 0.120$).

Variable	*Main Effect Time*	*Main Effect Group*	*Interaction Time × Group*
Jump Height	$F(2,194) = 43.5$**	$F(1,97) = 6.87$*	$F(2,194) = 4.25$
Jump Power	$F(2,194) = 37.8$**	$F(1,97) = 5.92$*	$F(2,194) = 2.85$
Max Strength	$F(2,194) = 56.3$**	$F(1,97) = 9.12$**	$F(2,194) = 5.67$*

Table 3. ANOVA results. **p < .05; *p < .001

Post-hoc comparisons were conducted using independent sample t-tests to examine differences between Group 1 and Group 2 at different time points (T0, T1, T2). Further pairwise comparisons were performed to analyse temporal differences within each group (T0 vs. T1, T1 vs. T2, T0 vs. T2). Dependent sample t-tests were applied with Bonferroni correction for multiple comparisons.

3.1 Jump Height

At T0, Group 2 had a mean jump height of 35.2 ± 2.5 cm, slightly higher than Group 1, which recorded 34.8 ± 2.4 cm. This difference was statistically significant ($p = 0.04$), with an effect size of $\eta^2 = 0.16$. At T1, both groups demonstrated a significant increase in jump height, with Group 2 achieving a greater improvement, reaching a mean value of 40.1 ± 2.8 cm, compared to 39.0 ± 2.6 cm in Group 1. This difference was statistically significant ($p < 0.001$) and associated with a larger effect size compared to T0 ($\eta^2 = 0.22$). At T2, the mean jump height values declined in both groups, but Group 2 maintained a higher average (38.5 ± 2.6 cm vs. 37.9 ± 2.5 cm in Group 1). This difference remained statistically significant ($p = 0.03$), though with a more modest effect size ($\eta^2 = 0.10$).

3.2 Jump Power

At T0, Group 2 recorded a mean jump power of 410 ± 25 W, higher than Group 1, which had 405 ± 23 W. This difference was statistically significant ($p = 0.04$), with an effect size of $\eta^2 = 0.21$. At T1, both groups showed significant improvements, with Group 2 reaching a mean value of 460 ± 28 W, exceeding the 450 ± 26 W recorded in Group 1. The difference was statistically significant ($p < 0.001$) and associated with a moderate effect size ($\eta^2 = 0.37$). At T2, jump power values declined in both groups, but Group 2 maintained a higher mean value (445 ± 26 W vs. 440 ± 24 W in Group 1). The difference approached statistical significance ($p = 0.05$), with a small effect size ($\eta^2 = 0.20$).

3.3 Maximal Strength (Bench Press)

For maximal strength, at T0, Group 2 exhibited a mean value of 410 ± 30 N, which was significantly higher than Group 1, which recorded 400 ± 28 N ($p = 0.02$). The effect size was moderate ($\eta^2 = 0.34$). At T1, both groups showed clear improvements, with Group 2 reaching 470 ± 32 N, compared to 455 ± 30 N in Group 1. The difference was statistically significant ($p < 0.001$), with an effect size of $\eta^2 = 0.50$. At T2, maximal strength remained relatively stable in Group 2 (465 ± 30 N), while Group 1 experienced a decline (450 ± 29 N). This difference was statistically significant ($p = 0.03$), with a moderate effect size ($\eta^2 = 0.30$).

The percentage variation analysis showed similar improvements for both groups during the intervention at T1, followed by a performance decline at follow-up (T2). However, Group 2 demonstrated a greater ability to maintain improvements, particularly in maximal strength (see Table 4).

Parameter	*Group*	*Increase at T1 (%)*	*Decrease at T2 (%)*
Jump Height	Group 1	+9.3%	-4.0%
Jump Height	Group 2	+8.3%	-4.2%
Jump Power	Group 1	+12.2%	-3.3%
Jump Power	Group 2	+11.1%	-3.5%
Maximal Strength	Group 1	+13.8%	-2.2%
Maximal Strength	Group 2	+14.6%	-1.1%

Table 4. Percentage changes in performance parameters

4. Discussion

The analyses revealed a significant improvement over time for all examined variables ($p < 0.001$), with a peak in performance immediately after the 8-week intervention (T1), followed by a partial decline at the 12-week follow-up (T2). It should be emphasised that the values observed at follow-up (T2) primarily reflect detraining effects following the cessation of the intervention, rather than the stability of motor learning in a strict sense. Differences between groups at T2 should therefore be interpreted as differential resistance to performance decay. However, the internal focus group demonstrated greater stability in maximal strength over time, with a smaller reduction at follow-up compared to the external focus group (-1.1% vs -2.2%; $p = 0.03$). This suggests that internal focus may be particularly effective for static exercises, promoting more durable motor learning. In the present study, the term 'motor learning' is used to refer to the retention of neuromuscular performance adaptations, rather than to changes in movement quality or coordination. The results should therefore be interpreted as indicators of performance retention rather than motor learning in a qualitative sense. Regarding jump performance, both groups achieved significant improvements ($p < 0.001$), with an immediate advantage for the external focus. This implies that internal focus may be more effective for exercises requiring muscular control and stabilisation, whereas external focus could promote more rapid improvement in explosive movements (Wulf et al., 2007). For jump power, both groups exhibited comparable improvements ($p < 0.001$), suggesting that in explosive movements, the benefits of internal and external focus are similar. In contrast, for maximal strength, Group 2 displayed a significant advantage over Group 1, both immediately after the intervention (T1; $p < 0.001$) and at T2 ($p = 0.03$). This finding may indicate that internal focus contributed to more stable motor learning, particularly when the task was simpler and did not involve coordination or balance. The greater understanding of the biomechanical causes of movement likely allowed for better engagement of the agonist muscles, making the execution more optimised (Schmidt & Lee, 2011). This supports the hypothesis that internal focus is particularly effective for static exercises, as suggested in the literature (Chen, 2005). Several limitations should be considered in interpreting these results. Physical activity performed during the follow-up period was not rigorously monitored. Participants continued their regular school physical education classes and habitual sports activities, which may have influenced detraining rates. This aspect represents a limitation of the study and should be considered when interpreting the results. The use of a uniform training programme with identical exercises may have reduced the impact of instructional strategies, minimising task variations. Additionally, the short follow-up period (12 weeks) might have been insufficient to fully assess the long-term persistence of effects. Future studies should explore longer observation periods and greater exercise diversification to more precisely determine the impact of attentional focus strategies on athletic performance. Despite these limitations, the results suggest that the choice of attentional focus should be adapted according to the type of exercise and training objectives.

5. Conclusions

The findings of this study highlight the role of different instructional strategies in consolidating specific motor skills and enhancing learning stability in adolescent athletes. By examining the difference between cause-based instruction and effect-based instruction, it was observed that although both groups showed performance improvements with regular training, internal focus had a more significant impact on the long-term retention of acquired motor skills, particularly in static and relatively simple exercises, such as the bench press. The internal approach appeared to promote greater cognitive engagement, fostering more precise control over technical execution and enhancing long-term performance stability (Schmidt & Lee, 2011). This aspect could be particularly relevant during the motor development phase of young athletes, where learning quality is crucial for building efficient motor patterns. Thus, the integration of internal focus instructions should be considered a valuable strategy in youth training programmes, especially when the goal is to improve maximal strength and execution stability over time. However, the generalisation of these effects to other performance components, such as intermuscular coordination and postural control, requires further investigation. Future studies should explore the influence of internal focus in diverse sports contexts and more dynamic, complex exercises.

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