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Is holistic focus of attention equally effective to external focus in performing accuracy of table tennis forehand stroke in low-skilled players?

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Abstract

Background The holistic focus of attention due to promising motor learning and performance benefits constitutes an desired direction for scientific investigations in sports settings. However, the generalizability of its effect on various motor skills in table tennis requires further investigation. The study aimed to determine the impact of holistic focus of attention and proximal and distal external focus on the accuracy of the table tennis forehand stroke in low-skilled players.

Methods Eighty undergraduate physical education students were randomly assigned one of four groups: focus on the ball (GPEF, $n = 20$), focus on targets marked on the tennis table (GDEF, $n = 20$), focus on feeling smooth and fluid when playing (GHF, $n = 20$), and control group was subjected to none of the experimental factors (CNTRL, $n = 20$). The participant's task was to score as many points as possible by hitting the ball using the forehand technique in table tennis inside the three smallest targets marked on the tennis table. The data were analysed using one-way ANOVA and mixed-ANOVAs with repeated measures on the last factor. Post-hoc pairwise comparisons (Fisher LSD test) were conducted to estimate the statistical significance of the intra-differences between the results. Partial Eta squared and Cohen's d were calculated to estimate effect size.

Results The highest improvement of score results was observed in the group with focus on feeling smooth and fluid when playing, while the lowest was observed in the group with focus on the ball both on the post-test and delayed retention test. Nevertheless, each group significantly improved their score results on the post-test and the delayed retention test, which indicates that holistic focus, proximal and distal external focus, had similar effects on the accuracy of the table tennis forehand stroke in low-skilled players.

Conclusions The study found that holistic focus and proximal and distal external focus are equally effective in improving the accuracy of the table tennis forehand stroke for players with lower skill levels. We recommend that coaches and practitioners use holistic and external attentional focus cues to enhance motor skill performance in table

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tennis. For example, when teaching or improving the table tennis strokes, coaches can apply a holistic cue like "focus on smoothing out your wrist movement" or an external cue like "focus on the target area of the table".

Keywords Distal external focus, Proximal external focus, Motor performance, Racket sports, Verbal instructions, Motor learning, Skill acquisition

Background

Various methodological manipulations have been employed to improve motor skill acquisition and enhance motor performance in physical education, sports, and rehabilitation [1, 2]. In the literature, there is solid evidence that one of the common methods for enhancing motor learning and performance effectiveness is manipulating the learner's focus of attention induced by instructions [3, 4].

Attentional focus in motor learning refers to directing attention to specific aspects of movement or task performance [4]. Numerous scientific studies on motor learning and performance consistently demonstrate that an external focus of attention– such as directing attention to the equipment– leads to more effective results. In contrast, instructing performers to focus on their body movements, like their arm position (internal focus of attention), is less effective. Considering motor learning and improving sports skills under field-like conditions, research has demonstrated its effectiveness in various sports, such as golf [5, 6], ballet [7], and racket sports [8]. Moreover, Chua et al. [9] showed that an external attentional focus is superior to an internal focus of attention, whether considering motor performance or learning tests, regardless of age, health condition, or skill level. Typically, the "constrained action hypothesis" [10, 11] provides a compelling explanation for the superiority of this effect. This phenomenon indicates that an internal focus disrupts the natural control processes of the motor system, while an external focus enables automatic control processes to regulate movements.

The effectiveness of an external focus in improving performance depends on the distance of the attentional focus from the body. According to McNevin et al. [10] increasing the distance of an external focus (distal) compared to an attentional focus close to the body (proximal) can lead to motor learning benefits. Several studies support these findings. For instance, skilled golf players [12] and novices [13], novice dart throwers [14], children in standing long jump [15] (Experiment 2), experienced kayakers [16], and skilled volleyball players [17] have all shown performance improvements when external focus is directed further away from the body. However, Roberts and Lawrence [18] provided compelling evidence that beginners in an aiming task can significantly improve their performance by focusing on nearby targets rather than distant ones. In turn, Niźnikowski et al. [19] reported that proximal and distal focus of attention had similar effects on table tennis backhand stroke accuracy in low-skilled players. Singh and Wulf [20] indicated that the advantages of a distal external attentional focus seem especially pronounced in skilled performers. These findings indicate the need for further scientific exploration to fully understand how the distance of the external focus can improve motor learning and performance.

Evidence has consistently demonstrated the significant advantages of employing an external focus of attention over an internal focus [5, 9, 21] and a distal focus over a proximal focus [9]. An interesting field of scientific research is comparison of effectiveness alternative attentional focus strategies with external focus in motor learning and performance. In addition, certain motor skills, such as dance or ballet, can hinder the provision of specific external focus instructions. In such cases, holistic attentional focus can be adopted, which is defined as a focus on the general feeling or sensations associated with completing a movement [22]. Studies have indicated that holistic cues can be highly effective in specific scenarios. For example, focusing on cues such as "smooth" and "glide" cues were found to be effective in a simulated race-driving task [23]. In addition, focusing on kinesthetic cues such as feeling explosive and thinking the word "Go!" was equally effective as external focus cues in a standing long jump [24].

Recent studies have presented compelling evidence regarding the advantages of adopting a holistic focus of attention on motor learning and performance. Becker et al. [22] conducted a study comparing the effects of internal, external, and holistic attentional focus on standing long jump performance. Their findings revealed that external and holistic attentional focus were equally effective and superior to internal focus. Furthermore, Shin and Kwon [25] suggested that external attentional focus may be unnecessary for skilled golfers, highlighting the importance of holistic focus for improving players' attentional focus under pressure. Another study [26] showed that holistic and external attentional focus improved novices' learning of the badminton short serve. Zhuravleva et al. [27, 28] also showed the positive effects of holistic attentional focus on adherence and performance in college track and field athletes. Additionally, research has shown that external and holistic focus groups outperform the control group in the retention and transfer phases of learning badminton long-serve in novices [29].

Nevertheless, not all related research has shown the advantages of a holistic focus of attention. For example, in a balancing task in novices, an external focus of attention was more effective than a holistic focus [30]. Similarly, no significant difference was observed between the external and holistic focus of attention in a crawl swimming task performed by experienced youth athletes and novices [31] or in the learning of a soccer shooting task in children [32].

In summary, recent research has indicated that a holistic focus enhances motor learning and performance similarly to an external focus. However, the generalizability of this effect across various motor skills and populations remains to be determined, especially in table tennis [8]. Additionally, Saemi et al. [31] emphasize that the effect of holistic focus constitutes an interesting direction for scientific investigations due to its novelty. Furthermore, we note the lack of scientific evidence comparing the effectiveness of using holistic focus with proximal and distal external focus in sports settings with that of performing different levels of expertise.

Table tennis is characterized by spatial accuracy of motor skills performed in minimal time units and in constantly changing conditions [33]. The performing an accurate stroke in table tennis requires the player to have excellent coordination, mainly of the upper and lower limbs [34, 35], as well as the ability to differentiate kinesthetically, the so-called "feeling the ball" [36]. The ability to direct the ball to a specific place on the opponent's playing field at the right time proves the accuracy of the movement. However, this is not possible in table tennis without a high level of technical preparation and without "automatic" execution of strokes such as forehand and backhand. Thus, table tennis coaches and scientists face the challenge of continuously improving methods of technical training to enhance the learning and performance effects in this sports discipline [37]. In addition, there is a limited body of literature about effective attentional focus instructions provided for learners in performing and developing table tennis skills [8].

The holistic focus of attention due to its novelty and promising motor learning and performance benefits constitutes an interesting direction for scientific investigations. However, the generalizability of its effect on various motor skills and populations requires further investigation. Therefore, the aim of the current study was determine the impact of holistic focus versus proximal and distal external focus on the accuracy of table tennis forehand strokes in low-skilled players. We hypothesized that low-skilled players using a holistic or distal external focus would perform the table tennis forehand stroke more accurately than those in the proximal external focus in retention phase of the experiment.

Methods

Participants

Eighty participants ($n = 20$ women, $n = 60$ men) were recruited from undergraduate physical education courses. They completed thirty 45-minute table tennis sessions as part of the university curriculum. The sample size for this investigation was determined based on a review of previous studies with similar designs, such as $n = 14$ [31] and $n = 15$ [29]. In order to ensure sufficient statistical power, a power analysis was performed using G*Power Version 3.1.9.4 [38]. The analysis revealed that a minimum of nineteen participants per group were needed to detect a medium effect size ($f = 0.40$) with a power of 0.90 and an alpha level of 0.05. Given that a medium effect size of $f = 0.40$ is considered typical for interventions with moderate effects in behavioural sciences [39], this effect size was chosen to provide a reasonable balance between detecting meaningful effects and practical feasibility. Therefore, a sample size of twenty participants in each group was deemed appropriate, as it exceeds the required minimum for statistical power, allowing for more robust and reliable conclusions.

Participants had to meet the following inclusion criteria for the study: (a) had no muscoskeletal disease or injuries within the last three months, (b) had no previously organized professional table tennis practices, and (c) agreed to volunteer to participate in the present study. All participants were right-handed. The participants were randomly assigned to one of 3 experimental groups: GPEF (group of proximal external focus), with a focus of attention on the ball ($n = 20$; M_{age} = 22.20, $SD = 1.32$ years; $M_{body\ mass}$ = 74.35, $SD = 10.96$ kg; $M_{body\ height}$ = 174.55, $SD = 8.27$ cm), GDEF (group of distal external focus), with a focus of attention on targets marked on the tennis table ($n = 20$; M_{age} = 22.85, $SD = 1.73$ years; $M_{body\ mass}$ = 76.30, $SD = 11.98$ kg; $M_{body\ height}$ = 174.85, $SD = 8.42$ cm), and GHF (group of holistic focus), with a focus of attention on feeling smooth and fluid when playing ($n = 20$; M_{age} = 22.95, $SD = 2.14$ years; $M_{body\ mass}$ = 74.40, $SD = 11.34$ kg; $M_{body\ height}$ = 175.15, $SD = 8.33$ cm). The control group (CNTRL) was subjected to none of the experimental factors, but took part in follow-up studies at the same time as the experimental groups ($n = 20$; M_{age} = 22.40, $SD = 1.39$ years; $M_{body\ mass}$ = 75.05, $SD = 10.73$ kg; $M_{body\ height}$ = 176.30, $SD = 6.96$ cm). Each group had an equal number of male and female participants.

Each participant gave written informed consent and was of legal age (above 18 years old). The study design was conducted in accordance with the Declaration of Helsinki. The research was approved by the University of Lomza Senate Scientific Research Ethics Committee (document code: 4175500, date: 22.11.2021).

Experimental task

Participants were asked to score as many points as possible by hitting the ball into the three smallest targets marked on the tennis table (targets 1, 2, 3) using the forehand technique (Fig. 1). This task aimed to assess stroke accuracy rather than technical proficiency. The accuracy of all strokes was recorded by a table tennis coach with 12 years of experience. The participants were not given any feedback on their performance during the task.

Experimental design and procedures

The participants completed an experimental task during a pre-test, a practice phase, and a post-test, all on the same day. The post-test was performed immediately after the practice phase, and the retention test was conducted 24 h after the practice phase. A 10-minute break separated the practice phase from the pre-test. The practice phase and all tests involved 45 trials in three blocks, with 15 trials at each target. There was a 30-second break after each block. The experimental groups followed a similar design, except for the instructions during the practice phase. The participants from the GPEF group were instructed to "concentrate on the ball," the GDEF group was told to "concentrate on targets marked on the tennis table," and the GHF group was asked to "concentrate on feeling smooth and fluid when playing." At the beginning of each block, the experimenter provided verbal reminders regarding the attentional focus. No instructions were given regarding attentional focus in the pre-test, post-test, or delayed retention test. Before the pre-test and delayed retention test, the participants performed a 15-minute warm-up. The warm-up consisted of a general part– general development exercises while running: arm circles, step-together-step, cross-over step, skips, jumps, as well as static exercises in place: torso twists and bends, squats, wrist circles. The specialist part of the warm-up was conducted at the tennis table (different from the one used for the research) with a partner: forehand-to-forehand diagonal shots and backhand-to-backhand diagonal shots.

The experiment was conducted in a sports hall using a standard-size tennis table (ANDRO Magnum SC, Germany) approved by the International Table Tennis Federation. All participants used the same professional table tennis racket (blade ANDRO "Inizio ALL," Germany and Rubbers DONIC "Liga," 2.0 mm, Germany). Plastic table tennis balls (ANDRO POLY S* 40+, Germany) were thrown away by a table tennis robot (NEWGY Robo-Pong 1050, DONIC, Newgy Industries, Inc., Tennessee, USA), which was positioned in the middle of the table on the opposite side of the performer (Fig. 2). The robot was programmed with ball speed (level 13), frequency, i.e. the time between balls served (1.5 s; 40 balls/min), the angle of the robot head (level 6), and ball placement on the table (position: level 17). Before the tests and training session, the robot's ball throwing parameters were calibrated in accordance with the manufacturer's guidelines, i.e. throwing 5 balls at the central target on the table (according to Newgy table tennis robot owner's manual for models 2050 & 1050).

The accuracy of the forehand strokes during all tests was determined using the assessment proposed by Poolton et al. [40]. On the table, there were six squares (50 cm per side) and three smaller squares (25 cm per side) centrally located inside the furthest squares (Fig. 1). Three points were awarded when the ball landed on the smallest targets (targets 1, 2, 3), two points when the ball hit the large distal squares surrounding the smallest targets, and one point if the ball hit inside the three large proximal squares. No points were awarded if the ball did not hit any of the squares. A video camera (Sony Handycam DCR-SR75E, Japan) sampling at 50 Hz was positioned next to the table to record the accuracy of strokes.

The participants performed 45 trials, with 15 trials per of the smallest targets: 1, 2, or 3. Before every block, the experimenter instructed the participants which of the smallest targets they should hit with the ball (the order was always the same: in the first block, target number 1; in the second block, target number 2; and in the third block, target number 3). For example, shots that landed in target number 1 scored 3 points, those in number 4 scored 2 points, and those in number 7 scored 1 point, while balls landing in all other squares no scored points. The points were summed across all 45 forehand strokes to determine the final performance score. The reliability of this assessment was confirmed by the value of the intraclass correlation coefficient (ICC = 0.92, excellent reliability [41]).

Data analyses

The normality of the distributions was assessed using the Shapiro-Wilk test. The observed differences were assumed to be significant at a probability level of $p < .05$. The pre-test data were analysed using one-way ANOVA (GROUP - GPEF, GDEF, GHF, CNTRL). The post-test and retention data were analysed in GROUP (GPEF, GDEF, GHF, CNTRL) x post-test (post-test, pre-test) and GROUP (GPEF, GDEF, GHF, CNTRL) x delayed retention test (delayed retention test, post-test) mixed-ANOVAs with repeated measures on the last factor. Post-hoc pairwise comparisons (Fisher LSD test) were also conducted to estimate the statistical significance of the intra-differences between the results. Partial Eta squared (η_p^2) (0.01, small; 0.06, moderate; 0.14, large) and Cohen's d (0.2, low; 0.5, moderate; 0.8, high) were calculated to estimate effect size [42]. All the data were analysed using the STATISTICA software package (version 13, TIBCO Software, Inc.).

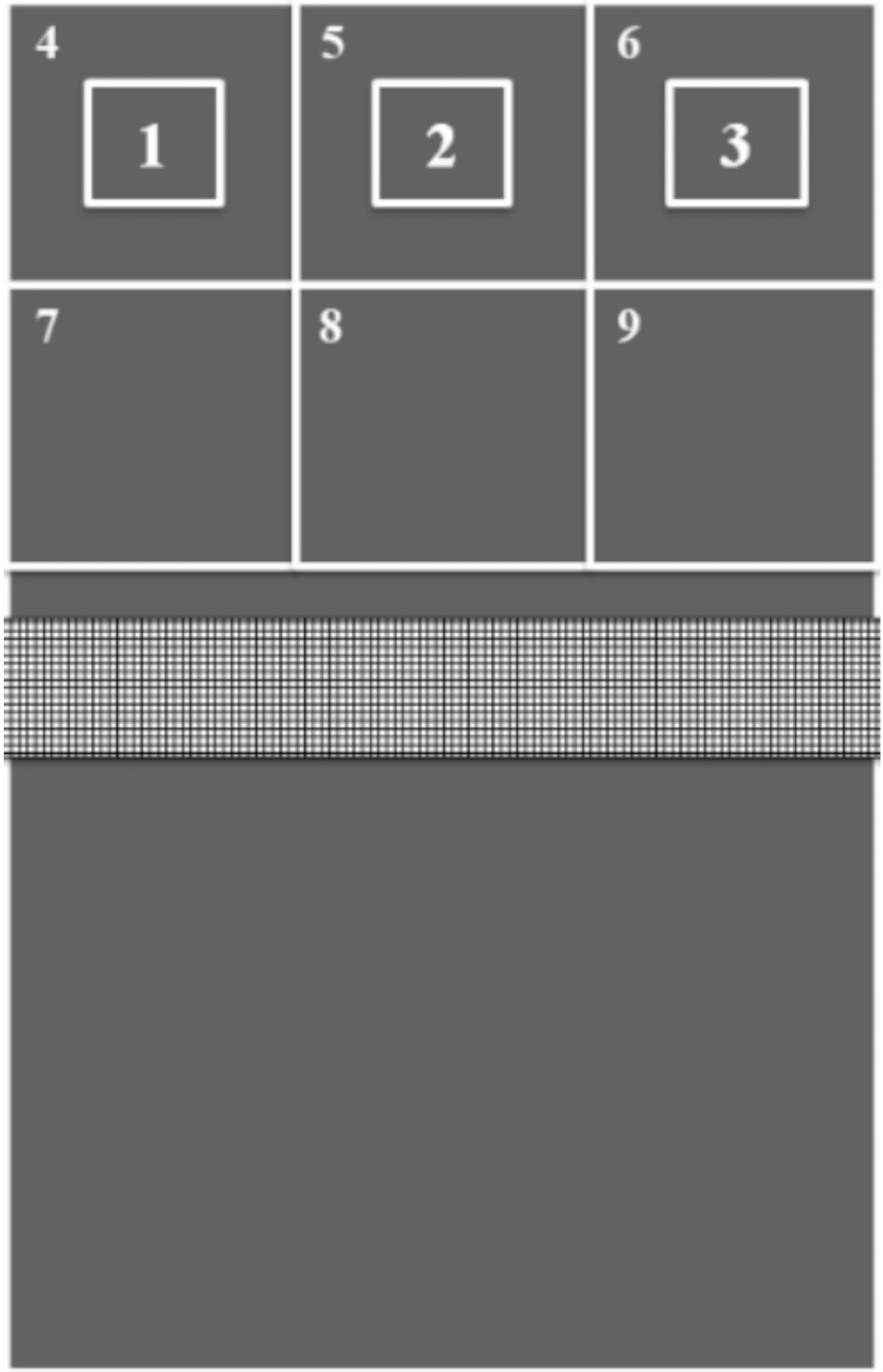

Fig. 1 An experimental accuracy task

Fig. 2 An experimental study station

Results

All the groups performed similarly on the pre-test (Fig. 3). There were no differences between the groups, $F(3,76) = 0.085$, $p > .05$, $\eta_p^2 = 0.003$. This suggests that the groups were comparable at the baseline level of performance.

On the post-test, there were no significant main effects of GROUP, F(3,76) = 0.881, $p > .05$, ηp² = 0.009, indicating that overall group differences did not emerge immediately following the intervention (Fig. 3). However, significant GROUP effects were observed in the delayed retention test, $F(3,76) = 5.123$, $p < .002$, $\eta_p^2 = 0.168$, indicating that group differences became evident after a period of time, suggesting the intervention had a lasting impact on performance (Fig. 3).

Interaction effects

The interaction between GROUP and TIME was significant according to the post-test $F(3,76) = 3.447$, $p < .02$, $\eta_p^2 = 0.120$) and the delayed retention test $F(3,76) = 15.998$, $p < .001$, $\eta_p^2 = 0.387$). This indicates that the effect of the intervention was different across groups and over time, suggesting that some groups retained the learned skills better than others (Fig. 3).

Post-Hoc comparisons

Post-hoc pairwise comparisons using Fisher's LSD test revealed several important findings. The Group of Holistic Focus (GHF) showed the most significant improvements in both the post-test ($p = .000001$, d = 1.107) and the delayed retention test ($p = .00036$, d = 1.083), indicating that this group demonstrated the greatest increase in shooting accuracy, which was both statistically and practically significant (Fig. 3). This suggests that the holistic focus intervention had a strong and lasting impact on performance.

In contrast, the Group of Proximal External Focus (GPEF) showed the lowest improvement, with no significant change in the delayed retention test ($p > .05$, d = 0.283). Although there was a modest improvement in the post-test ($p = .000001$, d = 0.418), the effect was small, indicating that this intervention had a limited practical

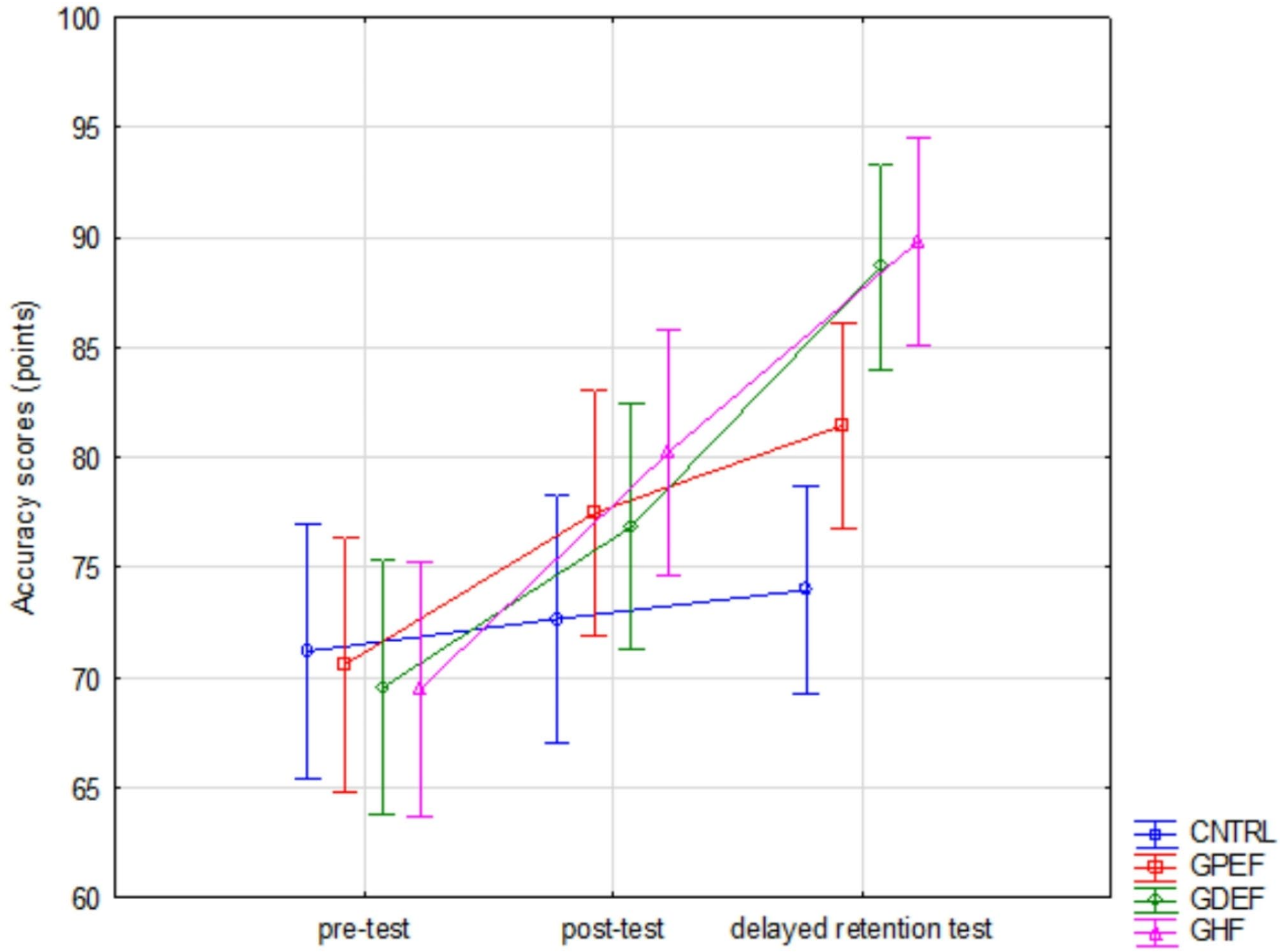

Fig. 3 Mean of the accuracy scores (points) during all study phases (pre, post, and delayed retention tests) for each group. Legends: CNTRL– control group (blue), GPEF– group of proximal external focus (red), GDEF– group of distal external focus (green), GHF– group of holistic focus (purple). Note: Vertical bars indicate 0.95 confidence intervals

impact on long-term performance (Fig. 3). This highlights the importance of choosing the right intervention method for sustained performance improvement.

The Group of Distal External Focus (GDEF) also showed significant improvements. Both the post-test (p =.00142, d = 2.197) and the delayed retention test (p =.000001, d = 1.125) indicated that this group demonstrated meaningful improvements in shooting accuracy, which persisted over time (Fig. 3). These results suggest that a distal external focus approach, while perhaps more gradual, can lead to significant and lasting improvements.

Finally, the Control Group (CNTRL) showed no significant improvement on either the post-test (p =.482, d = 0.113) or the delayed retention test (p =.1782, d = 0.221) (Fig. 3). This underscores the importance of the interventions in producing meaningful performance changes, as the control group did not benefit from any additional training or intervention.

Discussion

This study aimed to compare how adopting a holistic focus versus a proximal or distal external focus affects the accuracy of the table tennis test for forehand stroke. In our experiment, holistic instruction differed from external focus cues by emphasizing the feeling of executing the movement instead of impacting the environment. Our results indicated that the group with a holistic focus showed the greatest improvement in scores. In contrast, the group with a proximal external focus exhibited the least improvement in both the post-test and delayed retention tests. However, the three experiment groups had significantly improved scores on both tests, indicating that holistic focus and proximal and distal external focus had similar effects on table tennis forehand stroke accuracy in low-skilled players.

The lack of significant differences between the groups with external focus cues in the post-test and delayed retention test suggested that both proximal and distal external focus were equally effective in the experimental task. This finding is further supported by similar research conducted by Niźnikowski et al. [19], who used the same an accuracy test to assess table tennis backhand stroke among low-skilled players. Contrary to the findings of previous studies, our findings challenge the notion that distal and proximal external foci affect motor performance differently. Several studies [12, 13, 14, 16, 17] have suggested that increasing the distance of the external focus of attention, known as the "distance effect," improves motor learning [10, 43]. Furthermore, Singh and Wulf [20] argue that in regard to the "distance" of the external focus of attention, we should pay close attention to the performer's skill level.

Interestingly, the benefits of a distal external focus are particularly prominent in skilled individuals. This insight may shed light on the results of our study, as our experiment involved undergraduate physical education students who exhibited a high level of fitness but had limited experience in table tennis. For example, Robin et al. [44] suggest that skilled tennis players may pay more attention on the amplitude than on the direction of the stroke. In turn, in our experiment took part low-skilled table tennis players, for whom more appropriate was focus only on the direction of the stroke. Nonetheless, we suggest conducting additional research in this field.

Our study revealed no significant difference between the effectiveness of a holistic focus of attention and proximal or distal external focus. Therefore, we generally use the term "external attentional focus" to refer to both types of focus. Several recent studies [22, 26, 28, 29] have suggested that a holistic focus can enhance motor learning and performance similarly to an external focus. Our experiment supports this finding and suggests that a holistic focus can provide similar benefits to an external focus. The "constrained action hypothesis" explains the effects of attentional focus, stating that an external focus allows for automatic movement organization while an internal focus hinders it [3]. Building on this hypothesis, the OPTIMAL (Optimizing Performance through Intrinsic Motivation and Attention for Learning) theory of motor learning proposes that practicing under optimal motivational and attentional conditions leads to better performance [2]. Theory suggests that an external focus improves "goal-action coupling." Additionally, our study and the research by Vafaeimanesh et al. [29] indicate that a holistic focus may also enhance automaticity by directing attention toward the sensory consequences of movement. It appears that the holistic focus strategy can operate without requiring conscious control. Instead, it directs attention toward sensations of movement within the body, such as the feeling of smoothness, which could explain why both holistic focus and external focus cues have similar benefits.

The findings of our study align with the research conducted by Abedanzadeh et al. [26], which suggests that both holistic focus and external focus are beneficial for motor learning and performance accuracy-based tasks. Our study revealed that low-skilled players can benefit from a holistic focus. In addition, other studies have demonstrated the effectiveness of this approach for novices [26, 29], moderately skilled individuals [22], and skilled performers [25, 27, 28]. However, the limited research on this phenomenon makes further investigation of its replicability across different tasks and populations crucial.

Table tennis is a sport that heavily relies on kinesthetic differentiation ability and all its related aspects, often referred to as "sensation," such as "feeling the ball" [36, 45]. Therefore, using holistic attentional focus cues in table tennis is a reasonable approach. According to Hatami et al. [46], a mutual relationship exists between two attention factors– the external focus of attention and the absence of such attention– and muscles. The orientation of attentional focus has the potential to significantly impact the intensity of muscle contraction in table tennis when executing forehand strokes. However, this study did not compare other attentional focus strategies, such as internal, holistic, distal, or proximal external. By focusing on the feelings or sensations generated during the task, performers can avoid ineffective conscious control of their movement. Therefore, PE teachers and coaches should consider incorporating cues of holistic focus and external focus to enhance motor skills in table tennis. For example, when teaching or improving table tennis strokes, coaches can use holistic cues such as: "focus on smoothing out your wrist movement," "focus on fluid and rhythmic movement at the table," and "focus on feeling smooth and fluid when completing the serve." Alternatively, they can use external cues like: "focus on the ball's path," "focus on the target area of the table," and "focus on the movement of the racket." This may lead to more fluid, automatic movements that are essential in a fast-paced game like table tennis.

This study, however, is limited to analysing one particular stroke and cannot be generalized to the entire sport. Future research should explore the impact of a holistic focus and a proximal and distal external focus while examining other strokes in table tennis. The next limitation of our study were the lack of an internal focus group what limits the ability to compare the holistic focus with internal focus. Generally, this avenue of investigation holds great potential for further advancement in sports science, physical education, and rehabilitation.

Conclusions

To sum up, the study provides further evidence for the benefit of a holistic focus of attention. These findings suggest that there may be alternatives to using an external focus of attention. Further research could examine the effectiveness of mixed attentional cues, e.g., holistic-external and holistic-internal. However, there still needs to be more understanding of how effectively a holistic focus impacts the performance of complex motor skills among practitioners of varying skill levels. Therefore, we recommend conducting further research in sports environments to compare the effectiveness of holistic focus with internal focus, proximal and distal external focus. These studies should include participants with different skill levels, from novice to highly skilled practitioners.

Abbreviations

GPEF	Group of proximal external focus
GDEF	Group of distal external focus
GHF	Group of holistic focus
CNTRL	Control group
M	Arithmetic average
SD	Standard deviation
ICC	Intraclass correlation coefficient
η_p^2	Partial Eta squared
OPTIMAL	Optimizing Performance through Intrinsic Motivation and Attention for Learning

Supplementary Information

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Additional File 1: The detailed results of experimental groups.

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Author contributions
Conception and design of the study: W.Ł-A., P.A., T.N., J.S., A.M., W.R., E.N., P.R and M.S. Data acquisition: W.Ł-A. and P.A. Analysis and interpretation of data: W.Ł-A., P.A., T.N., J.S., A.M., W.R., E.N., P.R and M.S. Drafting the manuscript: W.Ł-A., P.A., T.N., J.S., A.M., W.R., E.N., P.R and M.S. All authors read and approved the final manuscript.

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Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
The study design was conducted in accordance with the Declaration of Helsinki. The research was approved by the University of Lomza Senate Scientific Research Ethics Committee (document code: 4175500, date: 22.11.2021). Each participant gave written informed consent and was of legal age (above 18 years old).

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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