The Effect of Parkour Activities on Specific Physical Fitness and Grit in the Population of Healthy Youth Football Athletes

Hasyim Hasyim[1]*, Hikmad Hakim[1], M. Rachmat Kasmad[1], Ramli Ramli[1], Iwan Setiawan[2], Ahmet Kurtoğlu[3], Karuppasamy Govindasamy[4], Joseph Lobo[5], Felipe Poblete-Valderrama[6], and Edi Setiawan[7]

[1] Faculty of Teacher Training and Education, Universitas Negeri Makassar, Indonesia
[2] Faculty of Teacher Training and Education, Universitas Negeri Jakarta, Indonesia
[3] Faculty of Sport Science, Bandirma Onyedi Eylul University, Turkey
[4] Department of Physical Education and Sports Sciences, Faculty of Science and Humanities, SRM Institute of Science and Technology, India
[5] College of Sports, Exercise and Recreation, Bulacan State University, Philippines
[6] Department of Sports Sciences and Physical Conditioning, Universidad Católica de la Santísima Concepcion, Chile
[7] Faculty of Teacher Training and Education, Universitas Suryakancana, Indonesia
* Hasyim Hasyim, corresponding author. Email: Hasyim@unm.ac.id
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Abstract

This study investigates the effects of parkour activity (PA) on physical fitness and grit for youth soccer athletes. True experimental research with a random control trial design for 12 weeks was adopted in this study. There were 78 male youth soccer athletes involved in the experimental (PA, n = 39) and control group (CG, n = 39) groups. The PA intervention program was carried out three times a week for 12 weeks. Pre-post-intervention tests were carried out to assess physical fitness and grit. The results of repeated measures ANOVA showed that there were significant effects of time, group, and time*group interaction on physical fitness (all, $p < .05$) and grit (all, $p < .05$). Meanwhile, Student's paired t-test results show that the PA group experienced significant differences scores between pre-and post-test in physical fitness (all, $p < .05$) and grit (all, $p < .05$), but in CG the differences were significant only occurred in sprint test 30m ($p < .05$), Illinois agility test ($p < .05$), hand grip test ($p < .05$) and there was no other difference, including grit ($p > .05$). In conclusion, we highlight that PA is the valid method to promote physical fitness and grit in youth soccer athletes.

Keywords

Grit; parkour activity; physical fitness; youth

Introduction

Soccer is the most popular team sport among the world community (Luo et al., 2023). Apart from that, soccer has characteristics of a fast game in attack and defense (Chmura et al., 2022), so athletes are required to do many movement skills such as running, jumping (Fischerova et al., 2021), and changes in direction (Michailidis, 2023). Data from previous studies reported that several components, such as physical fitness, were needed in competitive soccer games to support high performance in competition (Sermaxhaj et al., 2024). Physical fitness has been generally interpreted as the ability to carry out physical activities or sports without excessive fatigue (Luo et al., 2023). In the last few decades, athletes' physical fitness development has received special attention from coaches worldwide (Moran et al., 2022) because physical fitness significantly contributes to success or failure in competitive sports (Atan et al., 2023). Data and facts show that physical fitness has a vital role in athlete performance (Sammoud et al., 2024); for example, low physical fitness has the potential to cause fatal injuries (Gani et al., 2023), and ultimately has an impact on poor athlete performance (Akgümüş et al., 2023).

Meanwhile, high physical fitness has a great chance of providing athletes with achievements (Villaseca-Vicuña et al., 2021). Wang et al. (2023) reported that high physical fitness can maintain performance throughout the game. Apart from that, athletes also need to improve the quality of their physical fitness; therefore, grit is another aspect that needs to be considered in soccer.

Grit has experienced rapid development and has been widely studied by researchers worldwide (Lee, 2023). Grit is a theory that explains an athlete's ability to be persistent and enthusiastic in achieving long-term goals in sports activities (Mohebi et al., 2022). Grit has characteristics that could be demonstrated by two aspects, namely, consistency of interests (COI) and persistence of effort (POE) (Martínez-Moreno et al., 2021). The COI can be interpreted as an athlete's ability to pay great attention and focus on a specific goal (Jang et al., 2023). Meanwhile, POE is conceptualized as an athlete's ability to overcome challenges and difficulties to achieve their goals (Zhang et al., 2023). Data from previous studies documented that grit has a significant contribution to athletes playing competitive sports successfully (Haischer et al., 2021; Lee et al., 2021); for example, athletes with high grit are much faster in learning sports movement skills (Gray et al., 2023). Grit is also known to have a close relationship with high or low motivation and athlete satisfaction when training (Sumarsono et al., 2023). According to Cormier et al. (2024), grit has real benefits in encouraging athletes to take longer duration in training and has never given up spirit. Meanwhile, poor grit skills are the main factor that causes athletes to carry out physical activity and ultimately perform poorly (Rutberg et al., 2020). A study reported that grit can be a source of strength and weakness for athletes if it is not developed optimally by coaches (Frontini et al., 2021).

Considering the importance of physical fitness and grit for athletes in soccer, an effective form of training is needed, namely parkour activity (PA). The PA is relatively new, but its popularity has increased significantly in sports activities (Feletti et al., 2023; Strafford et al., 2022a). The PA is a physical exercise including running, hanging, jumping (Padulo et al., 2019), and climbing to pass through obstacles in the surrounding environment, such as walls and other objects (Strafford et al., 2022b). In addition, according to Williams et al. (2021), PA is a training that can be done indoors or outdoors, such as in a sports gymnasium or a city park. Based on previous studies, PA was not less effective than other types of training because

PA can improve several essential aspects in athletes, such as physical fitness (Dvorak et al., 2017; Grosprêtre & El Khattabi, 2022) and fundamental movement skills (Strafford et al., 2018). A recent study reported that using PA improved the quality of physical fitness and enjoyment among basketball athletes during training sessions (Williams et al., 2023). Even though PA provides several positive impacts for athletes and shows that parkour practitioners continue to experience gradual improvement worldwide, scientific knowledge regarding this practice is still minimal. Additionally, based on our knowledge, no previous studies investigated the effects of PA on improving physical fitness and grit in soccer athletes. Thus, we aimed to conduct a true experimental study with a random control trial (RCT) design for 12 weeks to assess the effects of PA on physical fitness and grit among novice soccer athletes.

Methods

Participants

Before true experimental research with an RCT design begins, G*Power analysis (v.3.1.9.4, Kiel University, Germany) with effect size = 0.65, α err prob = 0.05, and power (1-β err prob) = 0.80 (actual power = 81%), the results of these calculations show that the total sample size is 78 participants with a minimum of 39 samples needed in each group.

This research involved 80 male soccer athletes from the Physical Education department at Makasar State University (Indonesia) at the beginner level. They were selected based on inclusion criteria such as (i) novice athletes, (ii) not having any injuries, and (iii) not participating in competitive events at the national or international level. Meanwhile, the exclusion criteria are (i) participating in a competition and (ii) having an injury in the last three months. There were 78 out of 80 participants involved in this study because two participants suffered injuries. The participants were allocated into the experimental group (PA, n = 39) and control group (CG, n = 39) using a random number generator (RNG) application (See Figure 1).

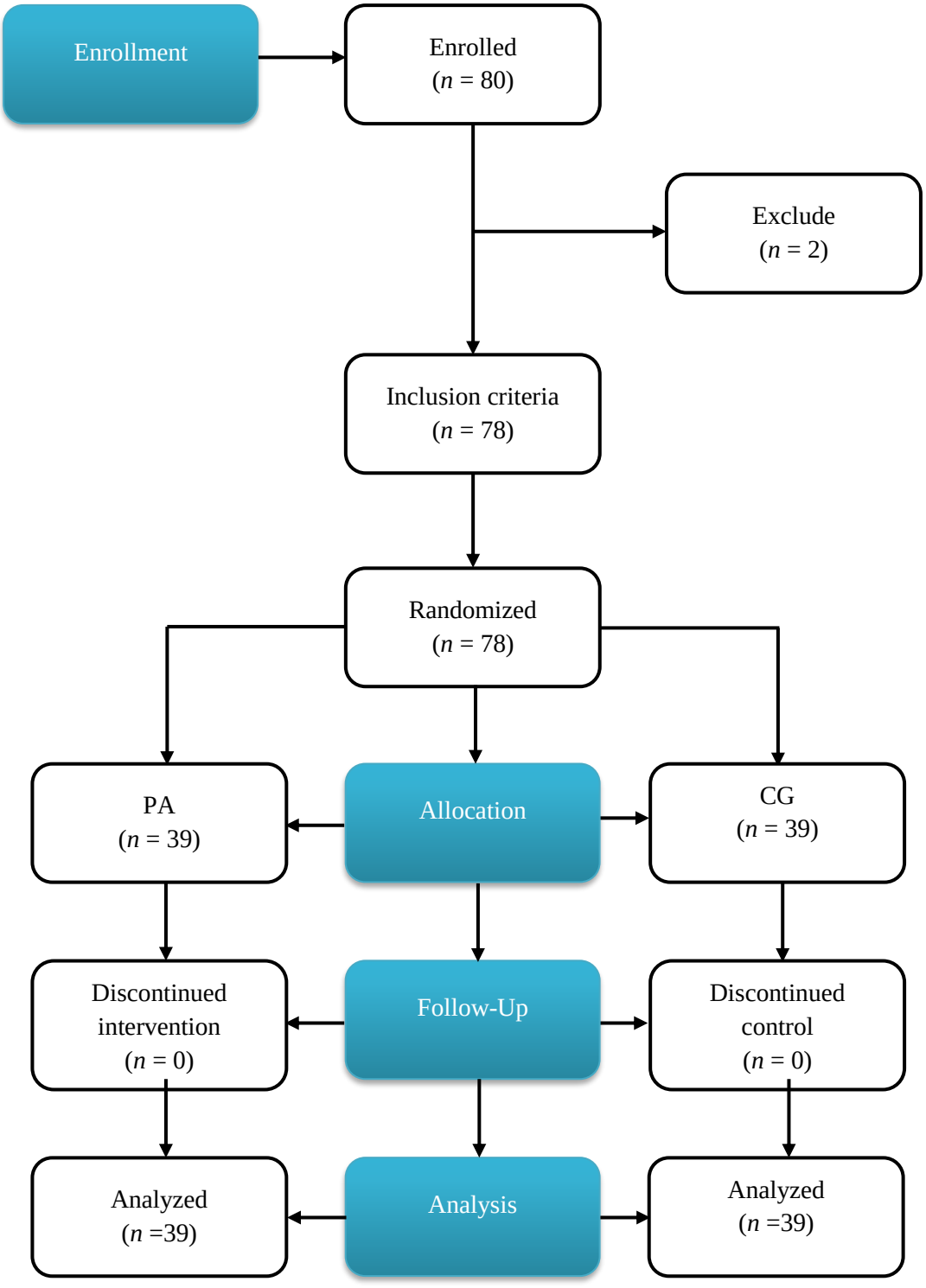
This research was carried out following the principles of Helsinki and was approved by the local ethics committee of Makasar State University with number 789/UNM-12/2023. In addition, because the participants in this study were under 20 years old, letters of consent were obtained in the form of signatures from the athletes, parents, and coaches. Information on participant characteristics is presented in Table 1.

Table 1: Information on the Characteristics of Experimental and Control Partners

Indicator	Mean ± Standard deviation
PA (n = 39)	
Age (years)	18.0 ± 1.01
Height (cm)	159.0 ± 2.89
Weight (kg)	56.5 ± 2.11
Body mass index (kg/m^2)	21.8 ± 1.05
CG (n = 39)	
Age (years)	18.3 ± 0.86
Height (cm)	160.0 ± 3.26
Weight (kg)	57.5 ± 2.87
Body mass index (kg/m^2)	22.0 ± 1.08

Note: PA = parkour activity; CG = control group

Figure 1: CONSORT Flow



Note: PA = parkour activity; CG = control group

Measurements

Physical fitness

We adopted the instrument from previous research to measure physical fitness among soccer athletes. The test items include:

Countermovement jump (CMJ)

The CMJ was chosen to measure leg muscle power in soccer athletes (Villaseca-Vicuña et al., 2021). This test was conducted using this method: the participants stood straight, their hands on their hips and gaze facing forward. When the coach instructed "go," participants bent their knees to 90 degrees and immediately pushed their legs to jump as high as possible. Participants have three times trials. The highest jump from three trials was recorded and selected for analysis.

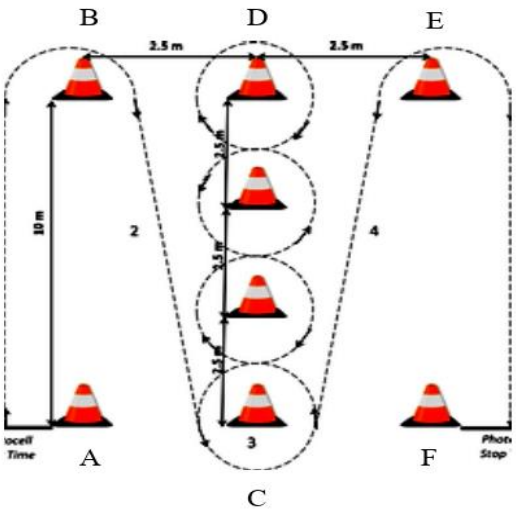
Sprint test 30m (ST30m)

The ST30m was used in this study to measure the running speed of soccer athletes (Christaras et al., 2023). This test was carried out by participants standing at the start line. After the coach instructed "go," the participants ran as fast as possible towards the finish line. Participants got three trials. The assessment was carried out by recording the duration needed to run from start to finish.

Illinois agility test (IAT)

The IAT was adopted in this study to measure the agility of soccer athletes. This test was carried out using the following method: participants ran from Cone A to Cone B and continued running towards Cone C. From Cone C, participants ran a slalom to Cone D, Cone E, and ended at Cone F. Participants had three times trials (Villaseca-Vicuña et al., 2021). The assessment was done by recording the duration needed to run from Cone A (start) to Cone F (finish) (See Figure 2).

Figure 2: Illinois Agility Test



Yo-Yo Intermittent Recovery Test Level 1 (YYIRL1)

The YYIRL1 was used to evaluate the endurance capacity of soccer athletes. This test was conducted as follows: After the audio sounded "beep," participants started to run from Cone A towards Cone B at a distance of 20m (must be reached before the next beep signal). After reaching Cone B, the participants recovered 10 seconds and ran again from Cone B to Cone A. This activity was repeated until the participant could not run or follow the "beep" sound. The running distance was recorded for statistical analysis (Villaseca-Vicuña et al., 2021).

Hand grip test (HGT)

The HGT (Takei Digital 5401, Japan) was used in this study to measure the maximum arm muscle strength level of soccer athletes. Based on previous studies, this instrument has shown high validity and reliability for measuring arm muscle strength (Strafford et al., 2022a). This test used the following method: the participants stood straight with their feet shoulder-width apart and gazes facing forward. When the coach instructed "go," participants gripped the hand grip device until it reached the maximum level. This test was conducted three times, each for the left and right hands. The highest value from each trial was used for analysis.

Grit scale

The grit scale is an instrument to measure grit levels in athletes. This grit scale has eight question items from two dimensions, namely: (i) consistency of interest (COI) has four question items (e.g., I always focus on one goal), and persistence of effort (POE) has four question items (e.g., I keep trying until succeed). This test used a Likert scale from points 1 = ("does not present my behavior at all") until 7 = ("it is similar to my behavior") (Sumarsono et al., 2023).

Study procedures

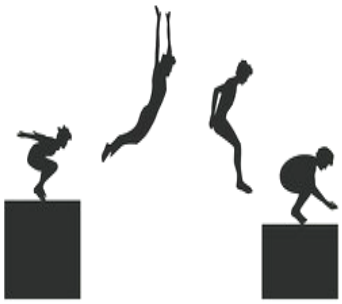
This research adopted a true experimental method with an RCT design for 12 weeks. This research was conducted from December 2023 to February 2024 at the Makasar State University gymnasium. The first meeting was on October 12, 2023. All participants carried out pre-test activities, namely physical fitness (e.g., CMJ, ST30m, IAT, YYIRL1, and HGT) and filling out the grit questionnaire (e.g., COI and POE). Pre-test activities were carried out from 7:00 a.m. to 10:00 a.m. In the second meeting on December 12, 2023, all participants in the experimental group conducted the PA program, while the CG group only carried out daily exercises (e.g., push-ups, plank, shuttle run) or did not receive any special program. The PA and CG activities were carried out until February 27, 2024. Then, on February 29, 2024, all participants carried out a post-test, namely: physical fitness (e.g., CMJ, ST30m, IAT, YYIRL1, and HGT), and filling out the grit questionnaire (e.g., COI and POE) from 7:00 a.m. to 10:00 a.m.

PA program

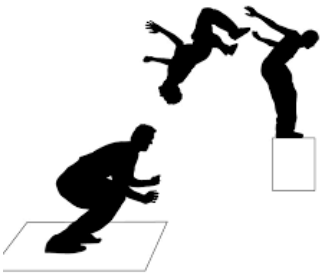
The PA program was held three times a week (Tuesday, Thursday, and Saturday) for 12 weeks in the gymnasium at Makasar State University (Indonesia). The research team designed the gymnasium as a parkour training area, with wooden blocks as obstacles that participants use to jump (See Figure 3). After the research team ensured this area was safe, PA was carried out from 7:00 a.m. to 8:00 a.m. The details of the PA program for 12 weeks are presented in Table 2.

Figure 3: Parkour Activity Area

Table 2: Parkour Activity Program for 12 Weeks

Type of training	Description	Repetitions x sets
Period 1 (Weeks 1 to 4)		
Jump and landing 	The athlete jumps from one wall and ends up landing on another wall.	Work: 2x2 Rest: 2 min
Pass vaults 	The athlete runs and then passes over a wall or object using one hand.	Work: 2x2 Rest: 2 min

Period 1 (Weeks 5 to 8)		
Handstand		
	The athlete performs standing movements using two hands (handstand).	Work: 3x2 Rest: 3 min
Kong vaults		
	The athlete runs and jumps over the wall using two hands.	Work: 3x2 Rest: 3 min

Period 1 (Weeks 9 to 12)		
Backflip		
	The athlete performs a backward jumping movement (back flip).	Work: 4x2 Rest: 4 min
Speed tic-tac actions		
	The athlete runs and jumps towards the wall and then returns to the other wall.	Work: 4x2 Rest: 4 min

Data collection

Data collection for this study included pre-test and post-test physical fitness (CMJ, ST30m, IAT, YYIRL1, and HGT) and filling out grit questionnaires (COI and POE). Pre-test and post-test data were collected at the Makasar State University gymnasium from 7:00 a.m. to 10:00 a.m.

Statistical analysis

All data obtained from physical fitness and grit tests were analyzed using Jamovi statistical software (v.2.3.28). Shapiro–Wilk analysis was chosen to test the normality of data, and the test results were assumed to be normal (all, $p > .05$). The mean and standard deviation were tested in this study. Parametric analysis using a two-way repeated measures ANOVA to investigate the effects of pre-test vs post-test (time) and PA vs CG (group) as well as the interaction between time*group on physical fitness (CMJ, ST30m, IAT, YYIRL1, and HGT), and grit (COI and POE). The students' paired t-test was used to detect mean differences between the pre-test and the post-test for each group separately. Partial eta-square (η2p) was used to determine effect size. The η2p value is between 0.01 to 0.06 (small), > 0.06 to 0.13 (medium), and the value > 0.14 (large). Meanwhile, the effect size is interpreted as Cohen's (*d*): 0.00–0.19 (trivial), 0.20–0.49 (small), 0.50–0.79 (moderate), and ≥ 0.80 (large) (Gaamouri et al., 2023). The significance level was determined as $p < .05$. The reliabilities of all dependent variables were assessed by calculating intra-class correlation coefficients (ICC).

Results

Test-retest reliabilities were generally above the accepted threshold, with ICC ranging from 0.92 to 0.98 (Table 3).

Table 3: Intraclass Correlation Coefficient of Change of Physical Fitness and Grit

Test	ICC	95% CI
Physical fitness		
CMJ	0.973	0.933–0.975
ST30m	0.986	0.972–0.991
IAT	0.974	0.941–0.963
YYIRL1	0.930	0.923–0.949
HGT	0.957	0.879–0.925
Grit		
COI	0.921	0.883–0.915
POE	0.937	0.928–0.944

Note: CMJ = countermovement jump; ST30m = sprint test 30m; IAT = Illinois agility test; YYIRL1 = yo-yo intermittent recovery test level 1; HGT = hand grip test, COI = consistency of interest; POE = perseverance of effort, ICC = intraclass correlation coefficient; CI = confidence intervals.

Table 4: Physical Fitness Changes from Pre-Test to Post-Test in Experimental and Control Groups

Outcome Measure	PA (n = 39)			CG (n = 39)			ANOVA		
	Pre	Post	Δ(%)	Pre	Post	Δ(%)	Time	Group	Time *Group
Physical fitness									
CMJ (cm)	17.6 ± 1.27	22.6 ± 1.27*	+28	17.6 ± 1.25	17.4 ± 1.20^{NS}	−1.1	F(1.76) = 322 p < .001** η2p = 0.809	F(1.76) = 88.2 p < .001** η2p = 0.537	F(1.76) =387 p < .001** η2p = 0.836
ST30m (s)	4.94 ± 0.55	4.16 ± 0.36*	−15.8	4.86 ± 0.55	4.63 ± 0.39*	−4.7	F(1.76) = 111.9 p < .001** η2p = 0.596	F(1.76) = 4.24 p = .043** η2p = 0.053	F(1.76) = 33.5 p < .001** η2p = 0.306
IAT (s)	17.8 ± 0.83	16.6 ± 0.70*	−6.7	17.5 ± 0.66	17.4 ± 0.63*	−0.6	F(1.76) = 72.0 p < .001** η2p = 0.486	F(1.76) = 4.69 p = .034** η2p = 0.058	F(1.76) = 50.3 p < .001** η2p = 0.398
YYIRL1 (m)	597 ± 67.2	825 ± 130.7*	+38.2	613 ± 60.7	608 ± 60.0 ^{NS}	−0.8	F(1.76) = 143 p < .001** η2p = 0.653	F(1.76) = 35.4 p < .001** η2p = 0.318	F(1.76) = 155 p < .001** η2p = 0.672
HGT (kg)	33.4 ± 1.87	36.4 ± 1.92*	+9.0	33.9 ± 1.71	34.4 ± 1.29*	+1.5	F(1.76) = 115.7 p < .001** η2p = 0.604	F(1.76) = 4.31 p = .041** η2p = 0.054	F(1.76) = 56.9 p < .001** η2p = 0.428

*Note: PA = parkour activity; CG = control group; CMJ = countermovement jump; ST30m = sprint test 30m; IAT = Illinois agility test; YYIRL1 = yo-yo intermittent recovery test level 1; HGT = hand grip test; Δ = change; NS = non-significant; η2p = partial eta-square; *significantly different from pre- to post-test values (at p < .05), **indicates significant values obtained by the ANOVA (p < .05)*

The two-way repeated measures ANOVA for physical fitness is presented in Table 4. The results show that there was a significant effect of time on physical fitness in the components of CMJ (p < .001), ST30m (p < .001), IAT (p < .001), YYIRL1 (p < .001), and HGT (p < .001). Significant group effects were found for the components of CMJ (p < .001), ST30m (p = .043), IAT (p = .034), YYIRL1 (p < .001), and HGT (p = .041). In addition, time*group interaction effects were found on the components of CMJ (p < .001), ST30m (p < .001), IAT (p < .001), YYIRL1 (p < .001), and HGT (p < .001). Meanwhile, Student's paired t-test results show that participants in PA experienced significant differences from pre- to post-test scores on CMJ (Δ +28%, d = -3.63 [large]), ST30m (Δ -15.8%, d = 1.47 [large]), IAT (Δ -6.7%, d = 1.28 [large]), YYIRL1 (Δ +38.2%, d = -2.03 [large]), and HGT (Δ +9.0%, d = -1.80 [large]), but in CG significant differences only occurred in ST30m (Δ -4.7%, d = 0.84 [large]), IAT (Δ -0.6%, d = 0.46 [small]), and HGT (Δ +1.5%, d = -0.44 [small]). There was no other differences. Significantly different pre-test and post-test physical fitness scores between the two groups can be observed in Figure 4.

Figure 4: Percentage Difference in Physical Fitness Scores from Pre- to Post-Test Between Experimental and Control Groups

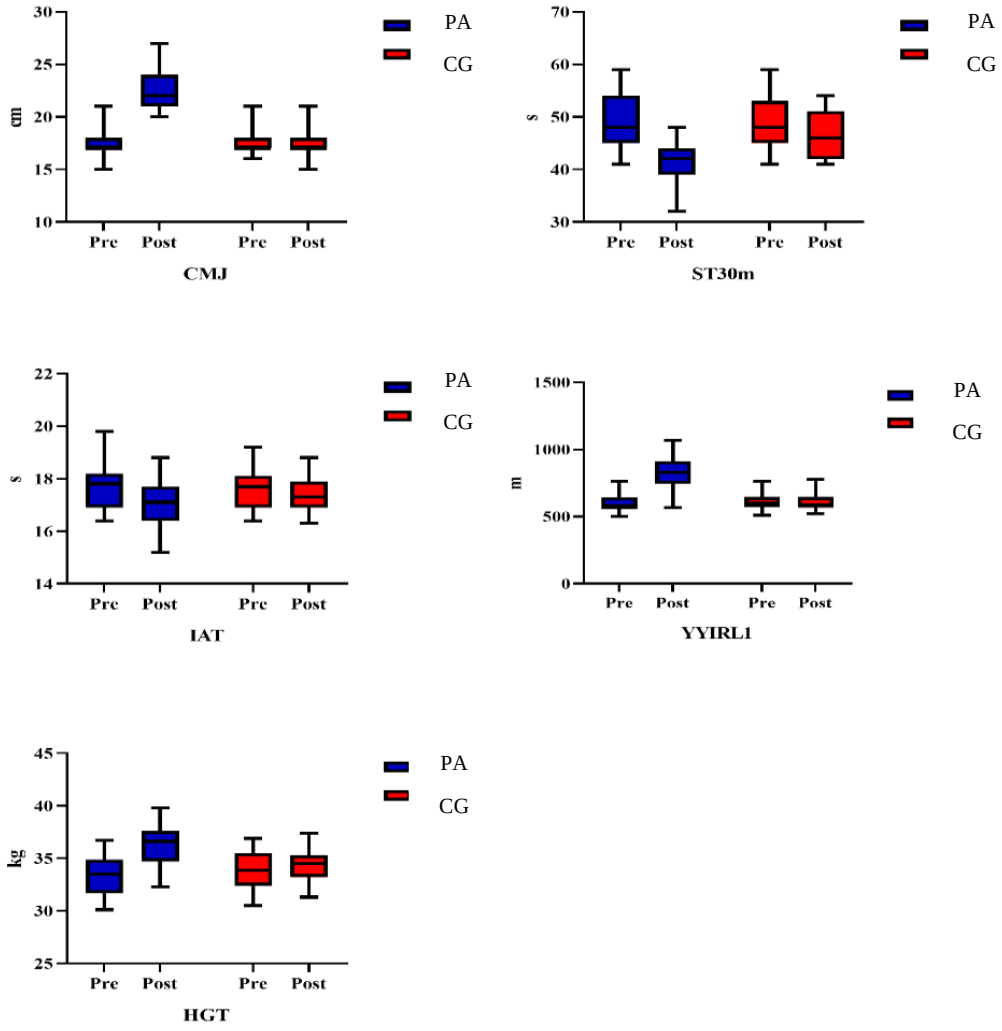
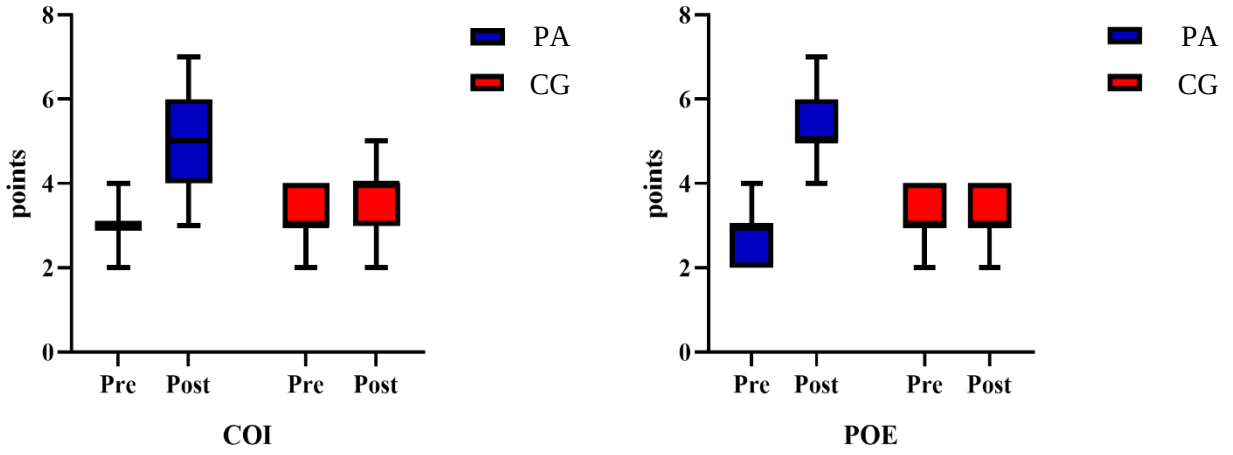


Table 5: Grit Changed from Pre-Test to Post-Test on Experimental and Control Groups

Outcome Measure	PA (*n* = 39)			CG (*n* = 39)			ANOVA		
	Pre	Post	Δ(%)	Pre	Post	Δ(%)	Time	Group	Time Group
Grit									
COI (points)	3.00 ± 0.60	5.13 ± 1.03*	+71	3.18 ± 0.55	3.15 ± 0.48^{NS}	−0.9	F(1.76) = 94.5 *p* < .001** η2p = 0.554	F(1.76) = 58.9 *p* < .001** η2p = 0.437	F(1.76) = 99.2 *p* < .001** η2p = 0.566
POE (points)	2.82 ± 0.68	5.49 ± 0.9*	+94.7	3.26 ± 0.71	3.23 ± 0.48^{NS}	−0.9	F(1.76) = 208 *p* < .001** η2p = 0.733	F(1.76) = 44.6 *p* < .001** η2p = 0.370	F(1.76) = 216 *p* < .001** η2p = 0.740

*Note: PA = parkour activity; CG = control group; COI = consistency of interest; POE = perseverance of effort; Δ = change; NS = non-significant; η2p = partial eta-square; *significantly different from pre- to post-test values (at p < .05); **indicates significant values obtained by the ANOVA (p < .05)*

Figure 5: Percentage Difference in Grit Scores from Pre- to Post-Test Between Experimental and Control Groups



The two-way repeated measures ANOVA for grit results are presented in Table 5. The results show that there was a significant effect of time for grit on COI ($p < .001$) and POE ($p < .001$). Significant group effects were also found for COI ($p < .001$) and POE ($p < .001$). Additionally, time*group interaction effects were found on COI ($p < .001$) and POE ($p < .001$). Meanwhile, from the results of the Student's paired t-test, we observed that participants in PA experienced significant differences in scores from pre- to post-test on COI (Δ = +71, d = -1.78 [large]), and POE (Δ +94.7%, d = -2.88 [large], but in contrast to the results in CG, there were no significant differences in COI (Δ -0.9%, d = 0.04 [trivial]), or POE (Δ -0.9%, d = 0.03 [trivial]). Significantly different pre-test and post-test physical fitness scores between the two groups can be observed in Figure 5.

Discussion

A true experimental study with a 12-week RCT aimed to test the effects of using PA on physical fitness and grit among entry-level soccer athletes. Based on our knowledge, this is the first PA study for novice soccer athletes at the novice level to investigate the effects of PA on physical fitness and grit.

The main findings in our study showed that the experimental group that implemented the PA intervention positively had a more practical effect than CG in improving physical fitness components (CMJ, ST30m, IAT, YYIRL1, and HGT), and grit (COI and POE) in athletes. It is because PA has several types of movements, such as jump and landing, pass vaults, handstands, kong vaults, back flips, and speed tic-tac actions, all of which impact the development of physical fitness. This aligns with previous studies, where male adolescents experienced increased cardiorespiratory fitness and strength levels after a ten-week PA program (Dvorak et al., 2017). Strafford et al. (2022b) reported that PA activities present motor skills (e.g., jumping, running, climbing), so it is an appropriate tool for developing basic elements of motor traits such as speed, strength, or agility. Meanwhile, other research explains similar results: PA is more prevalent among sports trainers because it is proven to improve poor physical fitness to high levels (Padulo et al., 2019). The direct evidence regarding the benefits of PA on the physical fitness and grit of soccer athletes is minimal; parkour activities have an essential role in developing athletes' performance in sports (Feletti et al., 2023; Islas & Varela, 2022). For example, recent research conducted by Williams et al. (2023) reported that PA maintained the quality of physical fitness while creating enjoyment among basketball athletes.

On the other hand, Grosprêtre and El Khattabi (2022) revealed that the main advantage of PA is in the type of movement (e.g., running, jumping, climbing, rolling) used to overcome an obstacle, so many athletes agree that this training very interesting, challenging and in the end, they continue to carry out this training. Furthermore, this study's results align with the results of Juan et al. (2022). PA is a valid alternative method for increasing the agility of 77 participants in physical education classes.

Finally, the main strength of this research is the implementation of a PA program three times a week with a duration of 1 hour per day for 12 weeks with elements of movement activities such as jump and landing, pass vaults, handstands, kong vaults, backflip, and speed tic-tac actions, to

trigger the development of physical fitness. The latest finding from this research is grit in novice soccer athletes. In addition, this PA program is designed in an ecologically closed environment (gymnasium), which provides a training experience that participants can easily learn. However, we acknowledge that there are several limitations to this study. For example, the participants only involved male athletes, which may limit the generalizability of the results. Second, the participants in the research only came from one university in Indonesia. It is recommended that future studies involve participants of all genders, both male and female athletes, from several universities in Indonesia or other countries.

Conclusion

In conclusion, it was confirmed that the benefits of PA could improve the physical fitness and grit of novice soccer athletes. These results show that physical fitness and grit improvements occurred in 12 weeks. Several practical implications may arise from this research. For example, the results of this research contribute as a reference for soccer coaches to create a training program by integrating PA. Apart from that, we recommend that soccer coaches and athletes continuously implement the PA program for the long term so that the athletes can achieve optimal performance in the future. It is expected that soccer athletes and other types of sports in Indonesia and other countries can use the PA program.

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