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Circuit training program improves agility and limb muscle power of basketball athletes

Program treningu obwodowego poprawia zwinność i siłę mięśni kończyn u koszykarzy

Faza Annasai[A,B,C,D], Sumaryanti(B,C,F), Sigit Nugroho[C,D,F], Sumarjo[D,E,F], Muhamad Ichsan Sabillah[C,D], Enggista Hendriko Delano[E,F]

Department of Sports Science, Faculty of Sports and Health Sciences, Yogyakarta State University, Indonesia

Abstract

Power and agility are important attributes for playing basketball. This study aims to determine the effect of a circuit training program on improving agility and limb muscle power in basketball athletes. An experimental method with a one-group pretest-posttest design was used. Purposive sampling with specific criteria was utilized: active basketball athletes aged 15-18 years, male, and willing to participate in the study. The sample consisted of 12 athletes who underwent a treatment consisting of 8 sessions over 24 meetings. The instrument for measuring limb muscle power was a vertical jump test, while the T-Test was used to measure agility. Data analysis involved normality and homogeneity tests, followed by t-tests using SPSS. The results showed that the average pre-test limb muscle power was 49.33 cm, which increased to 54.17 cm in the post-test (an increase of 4.84 cm). The average pre-test agility was 11.30 seconds, and it decreased to 10.33 seconds in the post-test (a reduction of 0.97 seconds). It can be concluded that the circuit training program can enhance the agility and limb muscle power of basketball athletes.

Keywords

circuit training, agility, limb muscle power, basketball

Streszczenie

Moc i zwinność są ważnymi atrybutami w grze w koszykówkę. Niniejsze badanie ma na celu określenie wpływu programu treningu obwodowego na poprawę zwinności i siły mięśni kończyn u koszykarzy. Użyto metody eksperymentalnej z jednogrupowym projektem przedtestowo-potestowym. Wykorzystano celowe próbkowanie z określonymi kryteriami: aktywni koszykarze w wieku 15-18 lat, płci męskiej i gotowi do udziału w badaniu. Próbka składała się z 12 sportowców, którzy przeszli leczenie składające się z 8 sesji podczas 24 spotkań. Instrumentem do pomiaru siły mięśni kończyn był test skoku w pionie, natomiast do pomiaru zwinności użyto testu T. Analiza danych obejmowała testy normalności i homogeniczności, a następnie testy t przy użyciu SPSS. Wyniki wykazały, że średnia początkowa siła mięśni kończyn wynosiła 49,33 cm, która wzrosła do 54,17 cm w teście potestowym (wzrost o 4,84 cm). Średnia początkowa zwinność wynosiła 11,30 sekundy, a w teście potestowym zmniejszyła się do 10,33 sekundy (redukcja o 0,97 sekundy). Można więc wywnioskować, że program treningu obwodowego może zwiększyć zwinność i siłę mięśni kończyn koszykarzy.

Słowa kluczowe

trening obwodowy, zwinność, siła mięśni kończyn, koszykówka

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Introduction

Basketball is a very popular sport and is increasingly embraced by the public, especially in Indonesia, both among adolescents and people of all ages [1]. With its growing popularity in Indonesia, basketball positively impacts the community and the region, especially among children, students, and college attendees. Basketball is played by two teams of 5 players each, aiming to score by placing the ball into the opponent's basket and preventing the opposing team from doing the same [2]. The vast interest in basketball consequently propels the sport towards high achievement. Attaining success in basketball requires dedication, but with continuous training, the pinnacle of achievement can be reached.

The techniques and physical conditions in basketball are sharpened through rigorous exercises such as warm-ups, game strategy training, passing, shooting, dribbling, rebounding, defense, and ball handling [3–5]. According to [6], exercise is a systematic and progressive sports activity carried out over an extended period, tailored to the individual, aiming to enhance the physiological and psychological attributes of humans to meet predetermined goals. Often, sports demand exceptional skills under intense physical stress, highlighting the pivotal role of physical conditioning in enhancing an athlete's performance [7]. Possessing a robust physical condition aids athletes in mastering and refining the fundamental techniques of basketball. Notable physical components in basketball include agility and power. Studies indicate a strong correlation between good basketball performance and physical tests like agility and jump tests [8]. Basketball players have shown that power and agility are crucial attributes for the game [9]. In a study [10], basketball players demonstrated superior agility compared to athletes in other sports. Agility, defined as the body's ability to swiftly change positions, plays an integral role in sports, particularly basketball [11]. This sentiment aligns with [12], who noted that agility enables individuals to rapidly and accurately alter their body's orientation. The agility in basketball contributes immensely to an athlete's ability to dribble the ball in varied situations and quickly change direction without losing balance [13]. Agility emanates from the explosive power or energy generated by muscle contractions, with the speed of these contractions being influenced by muscle fiber cohesion and neural impulse transmissions in the neuromuscular system [14]. Enhancing agility elements is expected to provide basketball players with robust power movements, thereby elevating their dribbling skills.

Basketball involves a dynamic set of multidirectional movements, prioritizing power for actions like running and jumping and directional shifts [15]. Power is defined as the force exerted during an activity at a specific speed [16]. [17] suggests that power is integral to jumping, influencing the explosive might of athletes in the anaerobic energy system; higher anaerobic energy correlates with higher jumps, vital for basketball players. Techniques like lay-ups, rebounds, and jump shots require athletes to jump, linking this action to game mechanics [18]. Such techniques necessitate limb power derived from anaerobic energy to achieve high jumps.

Based on observations in September 2022 at the Bantul basketball training center, a basketball coach indicated that his players' jump-shooting abilities were subpar. Despite possessing adept shooting techniques, an athlete's capacity to score can be hampered without sufficient jump height. Recent data collected from basketball coaches revealed that the average vertical jump was only 25 cm, categorizing it as below standard. The T-Test, used to measure agility, showed an average time of 11.50 seconds, also ranking below standard. Past training programs inadequately addressed agility and limb power, emphasizing more on endurance, speed, dribbling, and athlete competition.

Understanding the interrelation between agility and power in basketball players influences training methodologies, enabling the selection of optimal training techniques. Various training methods cater to an athlete's physical needs. Some studies recommend circuit training as an effective method to hone sports skills, power, and agility [19]. Individual circuit exercises involve seamless transitions between exercise types or stations, interspersed with brief rest periods [20]. A circuit training session encompasses a sequence of varied exercises, each performed for a set number of repetitions, followed by short rests before proceeding to the next exercise [21]. Diverse circuit training modalities include utilizing body weight as resistance [22,23]. Undertaking circuit training for 8 weeks has been shown to bolster agility and power [23,24]. Given the extant literature, it's posited that circuit training augments agility and the muscular power of limbs in basketball athletes.

Materials and methods

Study design

This research adopted an experimental approach, leveraging the one-group pretest-posttest design method.

Participants

The study took place at the Pundong basketball court in Bantul Regency from October to November 2022. The athlete population encompassed 30 individuals, with a sample size of 12. The participants, selected using purposive sampling, met specific criteria: active basketball players, aged 15-18, male, and willing to partake in the study. All participants provided informed consent, adhering to research ethics guidelines.

Instruments

The vertical jump test (measured in centimeters) was employed to assess limb muscle power, boasting a validity of 0.978 and reliability of 0.989 [25]. Agility was measured using the T-Test (in seconds), with a validity of 0.94 and reliability of 0.962 [26].

Research procedure

The circuit training regimen consisted of 1. Shuttle run, 2. Jumping jack, 3. Jump squats, 4. Zig-zag drill, 5. Burpee, 6. Jump lunges, 7. High knee, and 8. Lateral cone hops. The maximum heart rate (HRmax) was calculated using the formula (220-age). Training intensity was set at 50-70% HRmax, encompassing 12-15 reps per set across 3-4 sets. Rest intervals between stations/exercises lasted 15-30 seconds, and 3-minute breaks were allocated between sets. Assessments of limb muscle power and agility were conducted

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pre-training and after eight weeks of training. The entire exercise regimen spanned 8 weeks with 24 sessions, interspersed with pre- and post-tests.

Statistical analysis

Data were analyzed using the Shapiro-Wilk test to check for normality. Comparisons between pretest and posttest scores for limb muscle power and agility were made using homogeneity test results and the Paired Sample T-Test. Statistical analysis was performed using the SPSS version 25 software, setting the significance level at ($p > 0.05$).

Results

The analysis of average pre-test and post-test data involving study subjects showed a variation in limb muscle power and agility.

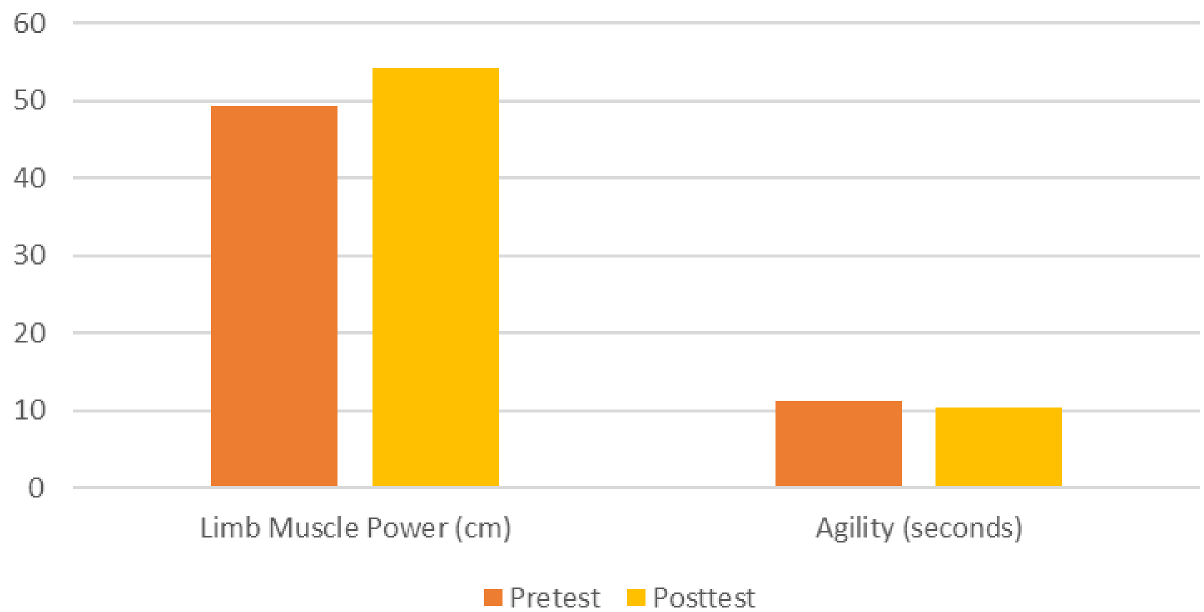

Figure 1. In the research that has been carried out in the form of pretest and posttest data on agility and limb muscle power

From Figure 1, there is a notable difference in the average increase of limb muscle power and agility between pretest and posttest. The average pre-test limb muscle power was 49.33 cm, while the post-test recorded 54.17 cm, showing an increase of 4.84 cm. Average pre-test agility was 11.30 seconds, which improved to 10.33 seconds in the post-test (a reduction of 0.97 seconds).

Table 1. Normality Test Results

Data		P	Sig.	Description
Agility	Pretest Posttest	0.881 0.510	0.05 0.05	Normal Normal
Limb Muscle Power	Pretest Posttest	0.816 0.467	0.05 0.05	Normal Normal

Table 1 indicates that the normality test was performed using the Shapiro-Wilk test technique. The sig. value for pretest agility was 0.881 > 0.05, and for pretest limb muscle power, it was 0.816 > 0.05. Meanwhile, posttest agility and limb muscle power recorded sig. values of 0.510 > 0.05 and 0.467 > 0.05 respectively. This confirms that all data related to limb muscle agility and power from pretest and posttest are normally distributed.

Table 2. Homogeneity Test Results

Data	Sig.	Description
Agility	0.535	Homogen
Limb Muscle Power	0.747	Homogen

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According to Table 2, the homogeneity test revealed significance values of 0.535 for agility data and 0.747 for limb muscle power data. This implies that the data set has homogeneous variance, indicating that the population data is homogenous.

Table 3. Paired t Test Results

Data	T table	T count	P	Sig.
Agility	2.201	7.969	0.000	0.05
Limb Muscle Power	2.201	4.994	0.000	0.05

From Table 3, the calculated t-value (7.969) surpasses the table t-value (2.201), and the p-value (0.000) is less than 0.05, highlighting the effect of circuit training on basketball players' agility. Similarly, Table 3 shows a calculated t-value (4.994) greater than the table t-value (2.201), and a p-value (0.000) less than 0.05. This signifies that circuit training impacts both the agility and power of basketball athletes' limb muscles. The paired t-test results confirm that if the calculated t-value exceeds the table t-value, the hypothesis stands validated.

Discussion

This research demonstrates that circuit training enhances both agility and limb muscle power. This might be due to basketball's inherent requirements such as initiating and maintaining transitions, frequent agility maneuvers [11], and quick decision-making on court [27, 28]. Power and agility crucially influence off-the-ball movements, impacting basketball techniques and tactics [29]. Basketball players need to exert high energy within short durations due to the sport's nature, necessitating elevated muscle power [30]. The ability to jump, a key success determinant in team sports, is primarily used to gauge lower limb power in athletes [31, 32]. Based on the studies, sports like basketball demand both agility and limb power, especially for jumping actions.

A prior research [15] emphasized the correlation between vertical jumping ability and power, influencing basketball skills such as shooting and rebounding. Elite basketball players execute between 40-60 high-intensity jumps and 50-60 speed and direction changes in a game, showcasing the importance of vertical jumping and agility for optimum performance [33–35]. Typically, a player will attempt 40-50 jumps per match, rapidly generating energy to rebound, block shots, and elevate jump shots [36]. This implies that skills like shooting, rebounding, and blocking require substantial power and agility.

Moreover, shooting from greater heights can augment shooting precision. Reports suggest that free-throw shooting accuracy is a distinguishing factor between winning and losing teams [37]. Research [38] has underscored the significance of lower limb power and jumping capability in basketball, emphasizing the positive relation between vertical jump prowess and 3-point shooting accuracy.

During circuit training, muscles transition swiftly from the eccentric to the concentric contraction phase. Utilizing stored elastic energy in muscles and muscle strain reflexes, this transition allows for augmented power during the concentric movement phase [39]. The adaptability and functionality of skeletal muscles can be influenced by adjusting exercise parameters like volume, intensity, and environmental conditions [40]. Studies on handball indicate that jumping exercises can enhance vertical jump height, attributed to better coordination and increased muscle power post-exercise [41]. In basketball, jumping engages specific muscle groups. Athletes require strong muscles like the quadriceps femoris, gastrocnemius, tibialis, medial vastus, and semimembranosus for optimum jumping [42]. Research [43] highlights the importance of type II muscle fibers for explosive actions like jumping. Factors such as age, gender, activity level, and experience can influence vertical jumping ability [44].

In circuit training, exercises like burpees engage multiple muscle groups, testing coordination, strength, and agility [45,46]. Findings from a study [47] after 8 weeks of bi-weekly circuit training exhibited improved neuromuscular control, agility, and power in the lower limbs. Circuit training is optimal for basketball players, enhancing jumping power, shooting precision, and agility [34]. The impact of circuit training on agility indicates a substantial correlation between maximum strength per body mass unit and quick directional change capability, termed as agility [48]. Circuit training is also beneficial for varied age groups, improving physical fitness [49]. The research conducted over 8 weeks with 24 sessions illustrated enhanced agility and limb muscle power in basketball athletes.

This study, however, had limitations like the short research duration, a limited sample size, and the inability to regulate the nutrition of participants. Further expansive research with larger samples and longer durations is encouraged. The findings can be valuable, especially for basketball training.

Conclusions

The findings conclude that circuit training can amplify the agility and limb muscle power of basketball athletes. With the pre-test limb muscle power recorded at 49.33 cm, the post-test showed an improvement to 54.17 cm, marking a rise of 4.84 cm. The pre-test agility was clocked at 11.30 seconds, which improved to 10.33 seconds in the post-test, showing a reduction of 0.97 seconds. This was reinforced after a t-test, which produced a limb muscle power result of 7.969 and an

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agility result of 4.994, both surpassing the table t-value at a significance level of 0.05 = 2.201. Circuit training is thus an effective methodology to elevate agility and limb muscle power in basketball players. This form of exercise can be instrumental in enhancing basketball players' physical conditions.

Adres do korespondencji / Corresponding author

Faza Annasai

E-mail: fazaannasai.2021@student.uny.ac.id

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