ORIGINAL ARTICLE

The effects of massed and distributed drills, muscle strength, and intelligence quotients towards tennis groundstroke skills of sport students

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Abstract

Background and Study Aim Basic forehand and backhand technical skills are the main requirements that must be mastered in playing tennis. Physical condition and intellectual intelligence were found to be the factors that affect the quality of tennis. On the other hand, limited learning time, and the number of teaching staff and facilities are classic challenges in the implementation of learning. This study describes the different effects of massed and distributed exercise, arm strength, and intellectual on the forehand and backhand skills of sports students.

Material and Methods A quasi-experimental method with two group pretest and posttest design approached the 64 volunteers of male sports students (age 19.3±1.7, BMI 20.17±1.47), who had attended the tennis course. The sample is divided into 2 groups of Massed Practices (MP) and Distributed Practices (DP) according to the score of the upper-arm strength and intelligence test. The anthropometrics were evaluated through digital microtome stature, the arm strength was evaluated with a push-up test and the kinesthetic perception was confirmed with the intelligence quotient (IQ) test. The prerequisite test employed Kolmogorov-Smirnov, while Bivariate analysis utilized the Independent Sample T-test and Paired Sample T-test of the SPSS 20.0 version.

Results The study showed that MP and DP had different positive contribution values to the tennis drive ($p=0.003$, $p<0.05$), while distributed gave a better contribution to the tennis drive with a significant value ($p=0.001$, $p<0.05$). The high arm muscle strength provides high accuracy in groundstroke ($p=0.003$, $p<0.05$), also for the high score on the intelligence test significantly affect the accuracy of tennis strokes ($p=0.000$, $p<0.05$).

Conclusions The results showed that there are differences in exercise methods, arm muscle strength, and intelligence quotient against tennis drive punches.

Keywords: massed, distributed, arm strength, intelligence quotient, tennis

Introduction

Tennis is one of the most popular racket sports across ages and genders [1]. It requires the linkage of bio-motor components including strength, speed, power, agility, and coordination [2], which is applied in a short-term and continuous explosive action that lasts for a long match duration [3]. Tennis has similar characteristics in competition load, intensity, and duration with other racket games [4], therefore, it is categorized as a high level of sports competition [5]. A tennis match can be played individually and in pairs, and has no time limit, so a four-hour match is possible [6]. In line with the statement, therefore high levels of physical, psychological, and technical efficiency are very crucial [7].

The basic technique of tennis stroke is divided into two groups of techniques, namely defensive punch, and attack punch techniques [8]. Defensive techniques are classified as push or slice and block punches, while attack punch techniques include drive, lob, spin, and overhead punches/smashes [9]. The serve, forehand drive, backhand drive, and volley are included in the basic techniques of stroke that must be mastered in tennis [10] through an appropriate training method [11]. The type of strokes is divided into groundstrokes, volleys, and overhead strokes [12]. The groundstroke is a crucial technique made by swinging a racket to produce a striking controllable force with high accuracy target, against a ball that has bounced off from the ground. The groundstroke can be done through forehand or backhand style on the side of the body [13], which is stated in the current study it requires a high level of footwork coordination and swing accuracy [14]. Forehand strokes are defined as strokes made to the right of the player for a right-handed hitter, while Backhand is a stroke made by swinging the racket from the player's left [15]. The implementation of forehand and backhand strokes in court tennis on groundstroke is carried out in three stages, namely backswing, forward swing, and follow-through [16].

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The findings of the current study explain that there is a positive relationship between training methods based on each individual's physical, psychological, and technical abilities towards improving the forehand and backhand abilities of beginner athletes [17]. It is understood that the training model which is based on the characteristics of each individual, provides better effectiveness. However, due to the limitation of learning time provided in 1 meeting session, accompanied by a large number of students, many obstacles were found in the learning process. In addition, the classic problem the form of limited teaching staff and training facilities, makes students have a long waiting time in carrying out independent practicum tasks one by one so that learning outcomes cannot be obtained optimally. Based on the facts, learning with effective strategies is needed to develop backhand and forehand drive skills in students.

Several studies illustrate the existence of training methods that can be used to improve tennis skills with limited time, a minimal number of coaches, and facilities, including Massed practice (MP) and Distributed Practice (DP). Massed practice (MP) is known as a method of setting a practical presentation turn for students in performing basic technical movements repeatedly without interspersed with rest periods [18]. Meanwhile, practice (DP) distributed is a method of practicing the various form of basic technique movements learned by providing a break between execution and rest time to alternate with other training partners through simultaneous instructions [19]. The study of movement skills explained that the massed practice method gave students more advantages in a longer implementation time to carry out basic technical exercises continuously. However, differences in physical conditions, movement skills, and other individual aspects were found to be obstacles to achieving learning outcomes. Therefore, another study concluded that the massed practice method will get optimal results for groups of students who have the same quality of physical condition and skills, but unfortunately are less than optimal for novice students [20]. The study of motion learning explains the positive results of distributed practice implemented in classes that have heterogeneous physical conditions and abilities, one of the findings is that the intensity of the exercise starts from low according to the ability of each student. On the other hand, several motor learning studies have confirmed that the implementation of distributed practice requires a long training time, and it is found that the results are less effective to be given to classes that have limited time, trainers, and facilities [21].

Coaches can use a variety of training methods and approaches to independently improve their tennis skills. However, the selection of learning methods should also pay attention to other supporting aspects such as differences in the characteristics of physical conditions, skills, and intelligence. The study of biomechanics explains that there is a significant effect between the strength of the swing force produced on the arm and wrist, the speed of the ball, and the level of accuracy produced [22]. Another study confirmed that according to the principle of impulse-momentum, the swing strength of a tennis racket can be optimally produced by transferring the force through contraction of the knee joint on the fulcrum, leg, hip, and shoulder followed by swinging the arm, and wrist which is carried out by synchronizing the movement simultaneously [23]. This illustrates that the strength of the swing force on the racket is largely determined by several aspects, one of which is the strength of the hand muscles.

In line with this explanation, another study confirmed that a series of simultaneous coordination movements in running, followed by hitting the ball firmly toward the desired target, requires high kinesthetic perception which is influenced by intellectual intelligence [24]. Neurophysiology studies explain that the ability and speed of the brain in understanding and interpreting stimuli received in the central nervous system, to be immediately transmitted to the motor nerves in producing motor movements, is largely determined by cognitive abilities [25]. Several measuring instruments described in the literature to determine a person's level of cognitive intelligence are through the intelligence quotient (IQ) test [26]. In line with this opinion, human movement studies explain the findings of the motor learning process of basic skills, where students who have low cognitive levels experience problems in understanding the basic movement tasks given [27], so have difficulty displaying the motion tasks into the form of psychomotor basic movements optimally [28]. Based on the explanations of several studies above which confirm that the basic forehand and backhand movement abilities are determined by elements of physical condition, biomechanical motion, and cognitive intelligence [11], hence the study to identify the difference in influence between massed and distributed methods in cases of learning with limited time, trainers and existing facilities at the Universitas Sebelas Maret is indispensable. This research aims to investigate the influence of training methods, arm muscle strength, and intelligence quotient (IQ) on tennis groundstroke skills in forehand and backhand of sports students at Universitas Sebelas Maret Surakarta. The results of this study are expected to provide additional literature regarding tennis coaches in schools in designing and modifying training models to improve basic technical skills for forehand, and backhand, including serve and smash.

Materials and Methods

Participants

This research was conducted at the Faculty of Sport Science, Universitas Sebelas Maret (UNY) which is located at Manahan Surakarta. The population taken in this study were 80 male sports student volunteers (age 19.3±1.7, BMI 20.17±1.47, RHR 63.4±8.2bpm), who have attended tennis lectures, passed the inclusion criteria and had no injury reports for the exclusion criteria. The sampling technique used purposive sampling which was carried out by taking subjects based on arm strength and intellectual quotient (IQ) score. The study begins with filled-out research approvals on anthropometric, health and physiological aspects, including the absence of cardiovascular risk, then signed a written consent under Indonesian law and university policies approved by the University Research Ethics (Approval Number KE/FK/112/EC/2021).

Research Design

The samples were categorized into 2 experimental groups namely the Massed Practices (MP) and Distributed Practice (DP) groups using ordinal pairing techniques based on the T-score of the arm muscle strength test and Intellectual Question test at the pre-test. Subsequently, all groups performed training drills of forehand and backhand groundstroke based on a training zone in moderate intensity at the initial stage, then increasing to the sub-maximum intensity at the final intervention according to the training guidelines of 5 minutes x 7-repetitions x 60%-80 % Intensity, with a rest between sets of 3 minutes and a rest set of 5 minutes repetitively. Upon completing the 6-week training drills, all groups were given the post-test intervention of the tennis drive test according to the *Hewitt Tennis test protocol* delivered for 3 times attempts, then the score recorded is the highest. The initial phase of the study began by providing the participants with informed consent, and the Physical Activity Readiness Questionnaire (PAR-Q) [29], to identify injury recording profiles and readiness for physical intervention at Sports Court, followed by the anthropometrical measurements, such as age, height, weight, and body mass index (BMI) using a digital microtome stature with an accuracy of 0.1 mm [30] and the resting pulse rate was taken under the palpation method in a sitting position by the Polar-H10 Chest Heart *Rate Monitor*

The tennis drive as a dependent variable was measured using the *Hewitt Tennis test protocol* [31], while the arm strength as an independent variable was tested using the 60 seconds Push-up test protocol [32], and intelligence quotient (IQ) was conducted using the *Intelligent Structure Test (IST)* 2000-Revised by a psychological specialist [33]. The forehand and backhand drive was conducted 3 times with 10 ball shots each attempt toward the selected target area to achieve the scores that have been determined according to the Hewitt test protocol. The push-up test was conducted in 60-seconds with 3-times attempts respectively. The IST consists of nine sub-tests that have a total of 176 question items. Each sub-test has a different time limit and is carried out briefly and administered manually [34]. One of the sub-tests that is relevant to a person's IQ in tennis is the WU sub-test, which consists of exercises in the form of blocks, and aims to measure spatial imagery, three-dimensional, analytical, and constructive technical abilities.

At the scoring stage, each sub-test is checked using the answer key provided. For all subtests (SE, WA, AN, RA, ZR, FA, WU, & ME), except for the 04-GE subtest, each correct answer will be given a score of 1, and incorrect answers will be given a score of 0. The provision of different score ranges is given specifically to the 04-GE sub-test, where several values are provided including 2, 1, and 0. The total score will be classified as a Raw Score (RW), then compared with the norms that have been provided to produce a Standardized Score (SW), which will become the standard of interpretation. The score will be classified as a Raw Score (RW), then compared with the norms that have been provided to produce a Standardized Score (SW), which will become the standard of interpretation. These nine subtests are interrelated with each other; therefore, the implementation of the test must be carried out quickly accompanied by the overall interpretation of the results.

Statistical Analysis

The data description employed the Statistical Product and Service Solution (SPSS) program for Windows, while the prerequisite test was performed using the Shapiro-Wilk method, homogeneity of variances. A Three-way ANOVA design with a 2x2x2 factorial design was used to determine the difference in influence between groups pre-and post-treatment and to identify which variable has the greatest impact on the treatment groups. The data were delivered as mean ± of standard deviation (SD), with a 95% confidence interval and statistical significance was accepted as $p < .05$.

Results

The profile of anthropometrical-, health, nutritional, physiological, as well as psychological respondents, can be seen in the following results.

The above result (Table 1) concluded that the respondents are in a healthy and fit state as indicated in the productive age group (18.27±1.09 yr.), have a normal level of body mass index (21.45±1.13kg/m^2), were not in fatigue (pulse 65.75±7.35bpm) and had normal intellectual scale as reported in the normal values for (102.8±3.63) and a normal distribution for muscular strength with (31.8±2.58) respectively. Simultaneously, a qualitative measurement was also conducted to obtain characteristics of the discrimination of arm muscle strength, intelligence quotient (IQ), and tennis drive including average grades, standard deviations, minimum values, maximum values, range of values, and the total number of acquisitions from measurement test results of each variable. The descriptive analysis of expected variables could be seen in the following table 2.

The results showed (Table 2) the different values of the research variables' mean and standard deviation with a significance level. The mean of Intelligence Quotient (IQ) differences in the pretest and post-test showed a value (r=90.50±13.11,) for Massed Practices (MP) group, while the group of Distributed Practice (DP) shows a mean value pretest and post-test with (r=90.82±12.25), thus could be concluded that the different value of Intelligence Quotient (IQ) for both groups in pretest are distributed in a similar level. In the Arm Strength variables, the MP group showed a mean value of (r=26.2±4.06), while the DP group's mean value was (r=25.85±3.74). It implies that there is no contrast difference in the mean value for both groups as shown in the similar value.

On the backhand drive value, the MP group showed a mean value (r=16.85±5.74), while the DP group had a mean of pretest and post-test value (r=16.17±2.49). Thus, it explains a significant difference in mean value both in the pretest and posttest for both groups have no significantly different value. For the Forehand drive, the MP group had a mean value of (r=13.85±1.21), while the DP group had a mean value (r=15317±1.91). It indicates that both groups have no significantly different mean of value in the pretest and posttest for forehand drive. In addition, Prerequisite calculations were also carried out in this study to identify whether the data were normally distributed. The following are the results of the normality calculation for

Table 1. Characteristics of Age, BMI, Resting Heart Rate, IQ, and Strength

Variable	n	Massed (MP)	Distributed (DP)
		Mean±SD	**Mean±SD**
Age (years)	64	18.23±1.17	18.31±1.02
BMI (kg/m^2)	64	21.12±1.56	21.78±1.25
Resting Heart Rate (pulse/minute)	64	63.4±8.2	68.1±6.4
Intellectual Scale (Score)	64	102.18±3.43	103.23±3.84
Arm Strength	64	31.37±2.32	32.23±2.84

MP - Massed Practices group; DP - Distributed Practice group

Table 2. Profile of Arm Strength, IQ, and Tennis Drive.

Variable	Groups	Number (n)	Mean±SD
Intelligence Quotient (IQ)	MP Posttest	64	92.83±12.51
	MP Pretest		88.17±13.71
	DP Posttest	64	91.71±11.98
	DP Pretest		89.93±12.52
Arm Strength	MP Pretest	64	29.8±4.40
	MP Posttest		22.5±3.73
	DP Pretest	64	28.6±4.17
	DP Posttest		23.1±3.32
Backhand Drive	MP Pretest	64	21.63±3.97
	MP Posttest		12.27±6.26
	DP Pretest	64	20.89±3.35
	DP Posttest		13.52±5.98
Forehand Drive	MP Pretest	64	21.73±4.38
	MP Pretest		11.98±5.76
	DP Posttest	64	20.98±4.61
	DP Posttest		12.27±5.15

MP - Massed Practices group; DP - Distributed Practice group hypothesis testing using the Kolmogorov–Smirnov Z (KS-Z) test with a significance level of α=0.05 as follows (Table 3).

Based on the results of the normality test (Table 3) using the Kolmogorov–*Smirnov Z* (KS-Z) test can be concluded that the variables including the arm muscle strength, intelligence *quotient* (IQ), and forehand dan backhand drive are shown in the normal distribution indicating the value greater than 0.05 *(p >0.05)*. Thus, the sample and variables in this study were indicated as a normally distributed population. The Paired Sample T-test was conducted to identify the different values of a variable before and after manipulation in the groups as well as to examine the different values between the two research groups. The result can be seen in the following table 4.

Table 4 shows the statistical calculation of 2x2x2 factorial on variable arm muscle strength, Intelligence quotient (IQ) on forehand and backhand abilities. In general, it can be found that there are differences in the degree of significance of the Arm Strength, Intelligence quotient (IQ) profile on the Forehand and Backhand abilities in both the Massed Practice (MP) and Distributed Practice (DP) groups. The results in the MP group in the sample with low arm strength and IQ showed low forehand results with a significance value of p = 0.017. Similar results were also shown in the MP group in the sample with high arm strength and IQ, showing also high forehand results with a significance of p=0001. Furthermore, the MP group in the sample with high arm strength and low IQ showed low forehand skills with a significance of p=0.007. Meanwhile, students with high arm strength, however, have a low scale IQ, and showed forehand skills on a moderate scale,

Table 3. The Normality of Forehand, Backhand drive, arm strength, and Intelligence Quotient (IQ)

Variable	Groups	Number (n)	Significance (p>0.05)
Forehand Drive	MP Pretest DP Pretest	64	0.556
	MP Posttest MP Posttest	64	0.917
Backhand Drive	MP Pretest DP Pretest	64	1.207
	MP Posttest MP Posttest	64	0.109
Push-Up	MP Pretest DP Pretest	64	0.009
	MP Posttest MP Posttest	64	0.671
Intelligence Quotient (IQ)	MP Pretest DP Pretest	64	0.062
	MP Posttest MP Posttest	64	0.724

*Significance (p >0.05)

Table 4. Paired T-Test

Variables	Group	Arm Strength	IQ	Tennis Skill	Significance (p<0.05)
Forehand	MP	Low	Low	Low	0.017
	MP	High	High	High	0.001
	MP	Low	High	Low	0.007
	MP	High	Low	Moderate	0.001
Backhand	DP	Low	Low	Low	0.024
	DP	High	High	High	0.001
	DP	Low	High	Low	0.002
	DP	High	Low	Low	0.001

Significance (p<0.05)

with a significance of 0.001. In addition, in the DP group, it was also seen that the sample with low strength and IQ was found to have low backhand skills with a significance of 0.024. The same pattern was also shown in the group of students with high arm strength and IQ, confirmed to have high backhand skill with a significance of 0.001. In the case of the group of students with low strength and high IQ, it was found to have low backhand skill with a significance of 0.002, as well as students with low strength and high IQ, were proven to have low backhand with a significance of 0.001.

Based on the statistical calculations above, it can be concluded that there are scientific evidence findings regarding differences in the strength of influence and the correlation between arm muscle strength, and intelligence quotient on forehand and backhand groundstroke abilities in the exercise group using the Massed Practice and Distributed Practice Group methods. The calculation of the significance value shows that high arm strength and intelligence quotient give significantly better results for forehand skills, compared to the group that has hand strength and low intelligence quotient in both study groups of Massed Practice and Distributed Practice. However, it can also be recommended that the results of this study can be generalized to groups of samples in the population with different numbers to obtain additional new data.

Discussion

The results showed that arm strength significantly influences the accuracy of groundstroke drive in tennis. The result is also strengthened by a similar study that states there is a significant contribution of the differences in training methods, and arm muscle strength towards the groundstroke ability in tennis drive. Similar finding is also stated by the current study that describes arm muscle strength as known to be an important factor to obtain optimal propulsion when making strokes in court tennis [1]. The study on Human Kinetics explained that greater arm muscle strength produces a strong hit with a high ball speed, the effect of the ball's gravity becomes low, and hence the ball is more controlled to be directed at the desired target [4]. In line with the findings, the effect of arm strength on force production was also explained in a biomechanical study which confirmed a positive correlation between a high level of arm strength on providing greater racket swing force [35], shortening the braking force of the ball while contact with the strings, thus produce in a greater ball bounce effect with a faster ball velocity [13]. It is expressed by the strength and conditioning study confirms that a high arm strength level provides a stable handgrip and stronger swing force on the racket [36], hence producing better racket control in both attacking and defending a position [21].

On the other hand, the findings of this study which state that there is no relationship between IQ scores of sports students on forehand and backhand skills are interesting to study further. These findings are debilitating neuro-cognitive studies that stated the existence of a positive influence between the level of intelligence on tennis skills. It is stated that intellectual intelligence has a prominent influence on the psychomotor intelligence of athletes [37]. Cognitive intelligence plays a role in the process of understanding and interpreting stimuli captured by the central nervous system [38], activating motor sensors, and executing movements as a reaction to stimuli with high coordination movements [39]. In this regard, neurophysiological findings also confirm that team sports athletes with high IQs tend to have good basic sports movement skills [40], and have a better quality of movement coordination in performing complex sports skill movements. It is highlighted by the motor learning study that the intelligence of students both during practice and competing proves to have a significant impact as a performance-determining factor for students in displaying a high level of movement skills [41].

Similar study confirmed that arm power can be significantly improved through the direct groundstroke drill that involves an arm muscle contraction in both directions of forehand and backhand alternately in the proper dose continuously [42]. Human motion study illustrated that a forehand drive movement skill in tennis is anatomically also influenced by antagonist muscle including a backhand motion that involves a posterior extension and abduction movement [43]. Consequently, it is required to implement an agonist and antagonist training method that continues to activate intramuscular coordination in both massed and distributed methods [44]. In line with the findings, the groundstroke skill is necessary for further review in the perception of the training methods, arm strength profile, and intelligence quotient that is assumed to be one of the scientific breakthroughs in training to improve the ability of tennis skill effectively and efficiently.

The study findings that explained there was no significant effect between intellectual intelligence on forehand and backhand abilities in this study, it was assumed that due to the limitations of the dependent variable, which only involved an intelligence test (IQ), contrarily does not involve other variables such as the Emotional Intelligence test (EQ). This opinion is based on growth and development studies which explain that intellectual intelligence has a significant reciprocal relationship to psychomotor abilities, and has a dominant role in forming mental attitudes, concentration, and focus when displaying motor skills [45]. The sports psychology study also explains that sports movement skills are not only influenced by IQ but also positively correlated to emotional intelligence [46]. Since tennis skills are affected by other variables including psychological domains that were not included in this study [47], it can be said that the measurement of tennis skills that only involves intellectual intelligence in this study is assumed not significantly correlated. This opinion is reinforced by the recent finding, which reveals that students with good IQ, supported with EQ and optimal muscle strength, have better groundstroke abilities [48].

The differences effect of exercise methods, arm strength, and IQ against tennis drive, however, require further scientific study. Another research expresses that traditional training drills improve the accuracy and stability more significantly of adolescent tennis players' strokes [49], meanwhile, the effect of machine-assisted training drills improves the stability of backspin strokes more significantly than topspin strokes [50]. It is strengthened by a current study that found significant differences in the groundstroke forehand ability between the drill training model employing a machine and a feeder [51]. In terms of the biomechanical aspects, a study shows a significant difference that athletes who use the foot position in a close stance provide better hitting accuracy and control compared with an open stance position during the groundstroke forehand driver [52]. This biomechanical approach can be used as a reference for learning basic stroke techniques by involving other bio-motor aspects, besides distributing proper methods of training according to the athlete's characteristics.

In the implementation of tennis training, it is necessary to pay attention to supporting factors such as the type of training method that is suitable for the athlete's characteristics, physical condition profile [53], and basic skills to be able to provide training loads according to abilities.

Determination of the right training method, cannot be separated from a series of learning processes or training processes that have been carried out in the form of special exercises, then gradually increased according to the development of the athlete's ability. The achievement of the quality of motion in groundstroke skills is influenced by several factors, namely basic movement abilities, exercises that have been experienced, a training environment with conducive feedback, and responsive trainers packaged with repetition of exercises and strengthening techniques [54]. In essence, groundstroke skills can only be learned or trained with certain requirements, including practicing these skills continuously for a certain sufficient period. This means that mastering tennis skills certainly takes time in practice and must be done continuously and systematically. One of the novelties and uniqueness of this study is that there is no correlation between IQ on forehand and backhand groundstroke abilities, while several studies explain that IQ is one of the determinants of the success of groundstroke skills. This difference in findings certainly cannot be generalized, therefore research involving more comprehensive samples and variables is needed to find out whether there are new findings related to the relationship between these variables and the tennis groundstroke ability of sports students.

Conclusions

The results of this study can be concluded that there is a correlation between exercise methods and arm muscle strength, but there is no correlation with intelligence quotient against tennis drive punches. But in this study, it is necessary to further identify the quality of physical condition, and the psychology of students to determine the achievement of court tennis according to the characteristics of the gender.

Conflict of interest

The authors declare no conflict of interest.

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