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THE EFFECTIVENESS OF SIX-WEEK BALANCE TRAINING WITH PERTURBATION INTERVENTION IN ENHANCING DYNAMIC BALANCE OF BASKETBALL PLAYERS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. It is known that all sports require dynamic balance and more specifically towards contact sports such as basketball which puts players through array of perturbation and collision during the game. The purpose of this study was to find out the effectiveness of six-week balance training with perturbation in enhancing dynamic balance of basketball players.

Materials and methods. The study participants were ten basketball players who volunteered and were randomly distributed into an Experimental Group (N=5) and a Control Group (N=5). The Experimental Group received a six weeks balance training intervention with perturbation for a total of 18 sessions, while Control Group kept regular training. The Y-balance test was used in pre-test and post-test to measure dynamic balance of both groups. Independent sample t-test was used for the analysis of results.

Results. The study findings revealed that the Experimental Group improved significantly in dynamic balance at p=0.000 after having undergone the 18 sessions of intervention with perturbation, while there was no significant improvement in the Control Group.

Conclusions. This study concluded that the six-week balance training with perturbation is effective in enhancing dynamic balance control in basketball players. This intervention can be modified or integrated into a neuromuscular training program to further improve dynamic balance of basketball players, hence, may help in reducing injury risk. This intervention also can be suggested as a training regime for other contact sports that require excellent balance control.

Keywords: basketball, dynamic balance, perturbation, proprioception.

Introduction

It is known that all sports requires dynamic balance and more specifically towards contact sports such as basketball which puts players through array of perturbation and collision during the game. Basketball continues to increase in popularity at all levels of play, from recreational to professional (Caine et al., 1996) and remains immensely popular, not just in the United States, but throughout the world (Cantwell, 2004). The basketball game place packed emphasize on the speed and power of athletes (Starkey, 2000). As stated by Meeuwisse (Meeuwisse et al., 2003), games were responsible for the majority of injuries causing more than seven sessions of time loss, resulting in a rate of severe injury 3.69 times greater than that of during practices. Hence, it can be foreseen that the frequency of injury during game was two times higher than during practices (9.9 versus 4.3 injuries per 1000 athlete-exposures) (Dick et al., 2007), According to Ferretti and colleagues (Ferretti et al., 1992) the frequency of injuries during a game is much higher than during a practice. It can be attributed to the high level of competition and the amount of effort that the players put into the game. They also noted that the increased risk of getting injured is caused by the high intensity of the competition. In games, fewer players generally participate, but the activity is usually at a very high level of intensity. This high intensity physical effort and its associated fatigue, combined

with a more unpredictable, competitive environment, may predispose game participants to acute injury compared with practice participants. As such, injuries during games were more likely to be due to player contact or other contact than were injuries occurring during practice (Starkey, 2000).

It is noted that unpredictable physical contact and perturbation is a factor to acute injuries when players are fatigue during intense games, also, they loss focus and their ability to maintain dynamic balance to resist the perturbation. Hence, this is when the injuries incidence rate increase. Furthermore, referring to Yde and Nielsen (1990), contact with other player was the main reason for time loss injuries; followed by non-contact injuries. As stated by Dick et al. (2007), half of the game injuries were coupled with player contact whereas nearly one fifth of game injuries were from contact with the floor.

Lee and Lee (2018) in their study indicated that great frequency of ankle and knee injuries in contact-sports among Malaysian athletes. A probable cause for the susceptibility of the ankle to be injured was its close proximity to the contact surface (e.g. equipment and opponent's body), which is the focus of activity in the contact-sports. They also found that the lower extremities (65.5%) were the common location for injuries in contact-sports. These findings were also similar with other studies (Choo et al., 2018; Lee et al., 2017). The researchers were also asserted that the lower extremities (51.1%) appear to be the most frequent site for the injuries as well (Choo et al., 2018). Injuries to the lower extremities especially knee and ankle regions were exposed to injuries at any time when the athletes with poor balance control required to run, turn, change of direction, and jump during weight bearing sporting activities. Consequently, they proposed that lack of balance control perhaps a contributory factor for lower extremity injuries (Choo et al., 2018; Lee et al., 2017). According to Cumps et al. (2007), rate of injury for player with poor balance was two to seven times compared with rate of injury for player with good balance. Poor balance ability has been significantly associated with an increased risk of ankle injury in a number of sports.

Generally sensorimotor or balance training programs are prescribed to improve balance ability. According to Teichmann et al. (2018), when sensorimotor or balance training has been incorporated into rehabilitation programs which can improve static and dynamic balance in both athletic and non-athletic populations. However, these rehabilitative exercises often represent relatively slow perturbations to human sensorimotor function (>350 ms), while empirical observations suggest that injuries occur in a time span of between 17 and 50 milliseconds after initial ground contact.

Fitzgerald et al. (2000) studied on efficacy of perturbation training in non-operative anterior cruciate ligament rehabilitation programs for physically active individuals. A group of subjects were received standard rehabilitation program and other group received the standard program augmented with a balance training with perturbation. Although both the standard program and the balance training with perturbation may allow individuals to return to high-level physical activity, the balance training with perturbation appears to reduce the risk of continued episodes of giving way of knee during athletic participation, and it allows individuals to maintain their functional status for longer periods.

Yom et al. (2014) conducted a study based on lateral in-flight perturbation during drop landings. They determined that lateral in-flight perturbations affect both frontal plane and sagittal plane lower-extremity biomechanics. Developmentally, these outcomes indicated that the athletes characteristically adjust their mechanics to land carefully after a semi-anticipated frontal plane perturbation, such as a push or a bump sideways by an opponent while in the air. Generally, the ability to generate sufficient, eccentric extensor and adductor moments about the lower extremity joints is of primary importance. Consequently, these researchers has demonstrated the importance of developing a proper dynamic balance and landing mechanics are crucial in reducing the risk of being in abnormal or excessive movement of biomechanics at the lower extremities. As a result, the reduced moment in hip abduction and adduction can decrease the shearing force and loading on the soft tissue causing less strain and hence reduce the likelihood of getting injured during in-flight lateral perturbation during games.

Therefore, this study was conducted to determine the effectiveness of six weeks balance training with perturbation in improving dynamic balance of university basketball players. The researcher is hoping that if this intervention is effective in improving dynamic balance, study finding may be beneficial and referred to basketball coaches and players to include this intervention into basketball training regime. With improved dynamic balance ability, it may reduce the risk of lower extremities injuries among basketball players.

Materials and methods

Study Design

This study used an experimental design to investigate the effectiveness of six weeks balance training with perturbation on dynamic balance among university basketball players. All ten eligible subjects who satisfied the inclusion norms were randomly allocated to either Experimental Group (EG) or Control Group (CG) by drawing an envelope indicating either EG or CG in order to eliminate bias.

Sampling Method

Purposive sampling method was utilized to recruit eligible subjects. The population in this study are Sultan Idris Education University Basketball players' age ranging from 20 to 25 years old. There were total of 60 Basketball club members with ten state representatives or advanced level players and ten intermediate or high school team representatives previously and five players with three years' experience and training and competing for UPSI Hystrix Basketball club. Besides the above mentioned basketball club members, there were non-club members i.e. recreational basketball players also volunteered in this study. The eligible subjects were screened using self-reported questionnaire. After the screening process, ten basketball players who fulfilled the inclusion criteria were recruited in this study as study subjects.

Inclusion and Exclusion Criteria

The subjects must be free from any lower extremities injuries and possess normal musculoskeletal functions in all joints within six months of participation. These

volunteers must have at least two years' experience in playing basketball. Subjects were included only if their vestibular and neurological functions were normal. University basketball players who had injuries within six months prior to this study and had impaired vestibular and neurological functions were excluded because these impaired functions would affect balance control.

Research Procedure

A total of ten subjects were randomly assigned into two groups i.e. Experimental Group and Control Group. The subjects in Experimental Group were undergone six weeks of balance training with perturbation while Control Group remained their normal training routine without any intervention. A written informed consent was distributed and subjects were required to fully understand the research procedures before participating in the study. They were allowed to withdraw in anytime without any reason given. The balance training with perturbation intervention consisted of 31 training variations. The experimental group was trained three sessions per week for six weeks with a total of 18 sessions. The control group remained their normal training without any additional intervention. Before starting the balance training with perturbation intervention (pre-test) and after balance training with perturbation intervention (post-test), all subjects were required to undergo Y-balance test for dynamic balance pre-test and post-test measures. The subjects in control group were also undergone pre and post-test procedures. Every subject from experimental group and control group was given one practice trial for familiarization of testing protocols. During the testing sessions, all subjects performed two trials and the average score was recorded for data analysis to avoid measurement error that may influence study results.

Balance Training with Perturbation Intervention

In this study, the experimental group was undergone the balance training with perturbation intervention while maintaining their normal training routine. Each intervention session lasted about 30 to 45 minutes. Warming up and cooling down sessions were involved before and after the training sessions. The balance training with perturbation intervention were designed to alter or modify vestibular input, and proprioception input to enhance sensorimotor integration in Central Nervous System (CNS). Proprioception input was modified with varies stances i.e. a) tandem stance, b) split squat stance, c) single leg stance, d) bilateral jumping and landing, e) single leg jumping and landing. Apart from progression in varies stances, vestibular input was challenged with various unexpected disturbance i.e. perturbation. Types of perturbation were differentiate by a) numbers, b) speed and c) predictability (i.e. constant or random). The intervention variations were progressed with the combination of various stances and types of perturbation on basis of simple and less challenging to complex and more challenging (Table 1). All training variations were progressed gradually as to challenge the vestibular and proprioception inputs which are important factors in improving dynamic balance to enhance the sensitivity of sensorimotor integration in CNS.

Table 1. Combination of Training Variations

Visual Eyes condition	Vestibular Types of perturbation	Proprioception Stance
	a. numbers	Tandem
	b. speed	Split squat
	c. predictability	Single leg
Open	-constant	Bilateral jumping and landing
	-random	Single jumping and landing

Research Measurement Instrument

The Y-Balance Test was utilized in this study as it is considered a useful tool in detecting injury susceptible subjects Gonell et al. (2015). Besides that, it has proven excellent levels of inter-rater test–retest reliability as reported in a study conducted by Lee and Ong (2012). The study revealed excellent test-retest reliability using Intraclass Correlation Coefficients i.e. 0.98, 0.98, and 0.99 on anterior, posteromedial, and posterolateral directions respectively.

The Y-Balance Test required subjects to balance on one leg while concurrently reaching as far as possible with the other leg in three different directions i.e. anterior, posterolateral and posteromedial (Figure 1). This test is used to measure the subject's strength, stability and balance in various directions. The subjects did a practice trial before testing sessions started. The subjects repeated the test with same leg for two successful reaches. After completed two successful reaches, they repeated this process with the other leg. Once subjects completed two successful reaches with each leg, they progressed to next test directions.

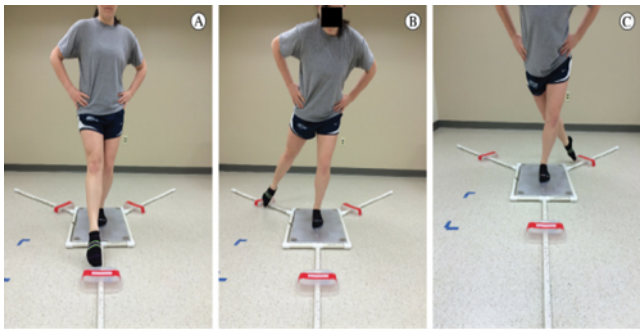

Fig. 1. Y- Balance Test

Statistical Analysis

Dynamic balance measures using Y-Balance Test were recorded and analyzed using independent sample t-test and paired sample t-test in Statistical Package for Social Science version 22. Independent sample t-test was used to compare the difference in dependent variable between Experimental Group and Control Group. The paired sample t-test was used to compare the difference on dynamic balance before and after intervention within Experimental Group to determine the effectiveness of balance training with perturbation intervention. The level of significance was predetermined at $p<0.05$.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration for human research and was approved by the Research Ethics Committee of the Universiti Pendidikan Sultan Idris.

Results

The demographic data of both Experimental Group and Control Group are similar in age, height and weight indicating that they were recruited from homogeneous group. The descriptive characteristics for these ten subjects in this study were shown in Table 2.

Table 2. Demographic Data of Experimental Group and Control Group

Variables	Experimental Group (n=6) (μ±SD)	Control Group (n=6) (μ±SD)
Age (years)	22.4 ± 1.34	23.6 ± 0.894
Height (cm)	169.8 ± 5.58	170.6 ± 5.72
Weight (kg)	64.0 ± 14.17	67.6 ± 11.41

Table 3 and Figure 2 portrayed the result of comparison between Experimental Group and Control Group for dynamic balance on absolute reach before the intervention. The pre-test value of dynamic balance on absolute reach between Experimental Group (79.44 ± 3.94 cm) and Control Group (78.66 ± 9.43 cm) revealed that there was no significant difference, indicating both groups were in homogeneous group (p = 0.869) before the balance training with perturbation intervention. After Experimental Group undergone 18 sessions of balance training with perturbation intervention, the result indicated there was significant difference for dynamic balance on absolute reach (p = 0.000*) between the Experimental Group (88.62 ± 4.51 cm) and Control Group (78.87 ± 9.05 cm).

Table 3. Pre-Test and Post-Test Between Experimental Group and Control Group for Dynamic Balance on Absolute Reach using Y-Balance Test Before and After Intervention

	Control Group (μ±SD)	Experimental Group (μ±SD)	p
Pre test	78.66 ± 9.43	79.44 ± 3.94	0.869
Post test	78.87 ± 9.05	88.62 ± 4.51	0.000*

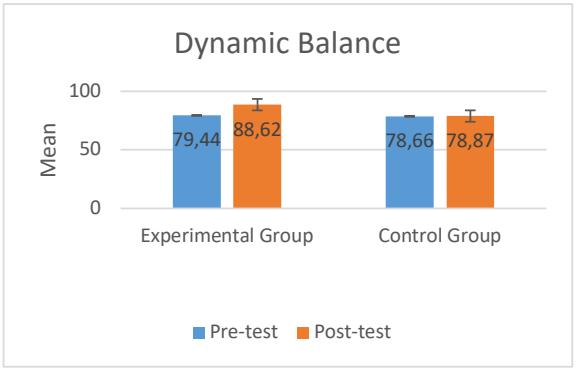

Fig. 2. The Mean of Experimental Group and Control Group for Dynamic Balance on Absolute Reach in Centimetres using Y-Balance Test Before and After Intervention

For the result before and after intervention of Experimental Group, after the 18 sessions of balance training with perturbation intervention, the mean of dynamic balance on absolute reach had increased from 79.44 cm to 88.62 cm (increased 9.18 cm). Study finding indicated that there was a significant improvement in dynamic balance on absolute reach (p = 0.000*) after intervention (Refer Table 4 and Figure 2).

Table 4. Pre-Test and Post-Test of Experimental Group for Dynamic Balance on Absolute Reach using Y-Balance Test Before and After Intervention

	Pre test (μ±SD)	Post test (μ±SD)	p
Experimental Group	79.44 ± 3.94	88.62 ± 4.51	0.000*

Discussion

The study finding indicated that the six weeks of balance training with perturbation intervention was effective in improving the dynamic balance of university basketball players. The Experimental Group obtained improvement in their dynamic balance after undergoing the balance training with perturbation while Control Group did not indicate any improvement because they only followed normal training routine without undergone any intervention. Withal, the dynamic balance improvement of Experimental Group was due to the progression of perturbation variations on different level of intensity to prevent plateauing. The progressively designed variations has challenged the proprioceptive input and vestibular input of the subjects by pushing on the subjects' shoulder with and without their knowledge which resulted in different forms of physiological stress that induced different neural and muscular adaptation (Lesinski et al., 2016).

In consequences, this finding has demonstrated that proprioception is an important factor in maintaining dynamic balance and sensing the position of limbs in space when vestibular and visual aspects of balance component is altered as proposed from a previous study by Irrgang et al. (1994), the vestibular system itself functions as an important apparatus that assists in maintaining the body upright against force of gravity. Whereas the visual aspects provide input to assist in balance control by counteracting the effect of head movement and the proprioception aspect receive inputs from the joints and surrounding structures and receptors to provide sensation of limbs in spaced. All these units must function optimally or dynamic balance will be affected after the postural perturbation.

This is in agreement with Lee and Lim (2020), as they trained Wushu players on trampoline to alter their proprioception. Their intervention were improved the dynamic balance of the subjects because of the repeated sensory feedback and continuous exposure to perturbation. In addition to that, the subjects were continuously challenged their postural changes and center of gravity trajectory while using trampoline. These things provided more challenging environment to proprioceptive input and vestibular input. By the rebounding nature of trampoline the vestibular input were also challenged and altered during perturbation.

The improvement of dynamic balance in Experimental Group is also due to the improved ability to maintain

dynamic balance in response to the balance disrupting force by perturbation or external forces, since the human body is not statically stable even during quiet double-limb stance, the Central Nervous System is constantly making adjustments to keep the center of mass over the base of support (Han et al., 2009). In previous studies, it is suggested that the Central Nervous System utilizes a "throw and catch" pattern to generate joint torques on opposite sides of the joint to maintain balance while standing. Henceforth, subjects were required to maintain dynamic balance while resisting against the balance disturbing force caused by the tension in the elastic tubing perturbation which will impose an accentuated neural training effect that can improve dynamic balance ability (Loram & Lakie, 2002).

Meanwhile, the manipulation of proprioceptive input and vestibular input through 31 combinations of variations is believed to be able to enhance the sensitivity of sensorimotor integration. Rapid sensorimotor integration from Central Nervous System indicating one has excellent dynamic balance ability. As stated by Piegaro, A (Piegaro, 2003), a four weeks balance training program is effective in improving dynamic balance significantly. Consequently, this explained that six weeks of balance training with perturbation is sufficient in inducing significant improvement in the dynamic balance of the experimental group in this study.

Furthermore, Cumps and colleagues (Cumps et al., 2007) reported that an improvement in balance ability is essential in reducing injury risk of basketball athletes. Therefore, when the experimental group displayed significant improvement in dynamic balance, it is a precursor in reduction of injury risk during game contacts.

Implications of Study

Study finding may help to explain the importance of dynamic balance on basketball players and other contact sports that required good dynamic balance control to reduce the risk of sustained lower extremities injuries. Therefore, it is suggested that this balance training program with perturbation can be considered to implement as one part of training regime for contact sports, hoping to improve dynamic balance of the players.

Conclusion and Recommendations

Dynamic balance ability is inversely proportional to risk of sustained lower limb injury and is important in improving sports performance in athletes especially basketball players. The six weeks balance training with perturbation revealed significant improvement in dynamic balance of Experimental Group. Hence, this intervention is essential for basketball players to improve their dynamic balance. It is suggested that this intervention could be modified or integrated into a training program to further improve dynamic balance of basketball players and other contact sports, indirectly, it may help in reducing risk of injury.

Imminent research may include larger sample size and longer intervention period. Stance variations and base of support may change to foam mats, tilt boards, seesaw apparatus such as tilting platforms and movable platforms to provide more difficult and challenging proprioceptive input and vestibular input. Intervention variations may design by considering the level of subject population and sports specific in order to challenge dynamic balance ability.

Conflict of interest

The researcher declares that there is no conflict of interest in this research.

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ЕФЕКТИВНІСТЬ ШЕСТИТИЖНЕВИХ ТРЕНУВАНЬ НА ЗБЕРЕЖЕННЯ РІВНОВАГИ З ІНТЕРВЕНЦІЙНИМ ЇЇ ЗОВНІШНІМ ПОРУШЕННЯМ У ПОКРАЩЕННІ ДИНАМІЧНОЇ РІВНОВАГИ БАСКЕТБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 2 рис., 22 джерела.

Історія питання. Відомо, що всі види спорту вимагають динамічної рівноваги, а особливо контактні види спорту, такі як баскетбол, який змушує гравців проходити цілу низку порушень рівноваги та зіткнень протягом гри. Метою цього дослідження було з'ясувати ефективність шеститижневих тренувань на збереження рівноваги в умовах її зовнішнього порушення в покращенні динамічної рівноваги баскетболістів.

Матеріали та методи. У дослідженні брали участь десять баскетболістів, які добровільно погодилися та були випадковим чином розподілені на експериментальну групу (N=5) та контрольну групу (N=5). Експериментальна група отримувала інтервенційні заходи у формі шеститижневих тренувань на збереження рівноваги в умовах її зовнішнього порушення протягом загалом 18 занять, а контрольна група продовжувала звичайні тренування. Для вимірювання показників динамічної рівноваги під час попереднього та підсумкового тестування в обох групах використовували тест на збереження рівноваги на базі підлогової платформи у формі літери Y. Для аналізу результатів використовували t-критерій Стьюдента для незалежних вибірок.

Результати. За результатами дослідження було встановлено, що показники динамічної рівноваги в експериментальній групі після проходження 18 занять у рамках інтервенційних заходів із зовнішнім порушенням рівноваги статистично значущо покращилися за рівня достовірності p=0,000, тоді як у контрольній групі статистично значущого покращення не спостерігалося.

Висновки. За результатами цього дослідження зроблено висновок, що шеститижневі тренування на збереження рівноваги в умовах її зовнішнього порушення є ефективними для покращення контролю динамічної рівноваги в баскетболістів. Ці інтервенційні заходи можна змінювати або інтегрувати до програми нервово-м'язових тренувань із метою подальшого покращення динамічної рівноваги баскетболістів, отже, з її допомогою можна знизити ризики травмування. Ці інтервенційні заходи також можна рекомендувати як режим тренувань для інших контактних видів спорту, які вимагають відмінного контролю рівноваги.

Ключові слова: баскетбол, динамічна рівновага, зовнішнє порушення, пропріоцепція.

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