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Original article

THE EFFECTIVENESS OF PLYOMETRIC TRAINING ON MUSCLE STRENGHT FOR SOCCER PLAYERS

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Abstract

Objectives. The aim of this study is to examine the effectiveness of plyometric training on muscle strength for soccer players in a project school in Kuala Lumpur.

Methodology. All 60 subjects were divided randomly into two groups (N=60). For the first 30 randomly selected were subjects grouped into the controlled group (N=30) and the other class consisted the treatment group (N=30). The study used the quasi experimental method with pre-post-test designing and standing broad jump as measuring instrument. The acquired data was analysed based on the matter of the study; that is about the difference of the mean between the two study groups. Paired t-test was used to make a comparison to see each group's level of improvement in skill.

Result. The findings showed that the treatment group showed a significant difference ($p=0.00<0.05$). It is suggested that the treatment group's mean (M=9.57) was much better than the controlled group's (M=5.80). This based on the different outcome of the post and pre-post and pre test after six weeks of treatment practice with plyometric.

Conclusion. The implication shows that plyometric training can enhance strength among football players. Coaches and teachers should look into essential factors that play an important role in developing the powers, skill and overall strength of our football players.

Key words: Effectiveness, Plyometric training, muscle strenght, soccer.

Introduction

The concept of plyometric is a training that provides extra stresses towards the muscles during pre-stretching phase and stretching reflex done during muscle shrinkage (Radcliffe & Farentinos, 1999). This will increase the explosive energy production. Repeated trainings in a set of exercises will provide maximum impacts. According to Chu (1998), present plyometric training (PT) has been known by a number of coaches and athletes as one of the training method for increasing muscular abilities. In the early 1970s, it was made practical for track events and by the 1980s it was used by coaches for other sports such as weightlifting, volleyball and soccer. For soccer, that requires skills such as kicking, running and holding a ball, muscular strength on the legs is needed. When jumping to make a header for a striker or a save by a goalkeeper, the height of a jump depends on the level of muscular strength on the legs. Therefore, each player must possess a certain level of muscular strength and power on the legs to challenge the strength of the opponent players as well as able to perform the skill at a high consistency level. In a plyometric training programme, a lot of benefits can be achieved. It will affect daily behaviours, strength level, accurate running technique and initial touch on the surface of the ground. The combination of these training benefits is suitable to be applied by coaches in increasing players' performance (Fox & Mathews, 1981).

Methodology

Framework..The framework of this research utilized the quasi-experimental method with pre and post tests. The subjects were divided into control and treatment groups. The treatment group had to undergo track and plyometric trainings that were consisted of five stations within the duration of six weeks. The plyometric training consisted of exercises such as standing jump over barrier, side to side ankle hop, and two foot ankle hop. For the control group, the subjects had to only undergo track trainings that cinsisted of five stations. The track trainings conducted were distance jump, leg curl, chin up, shooting and sprints.

*Sampling.*The researchers had randomly selected 60 students. Based on the total number of selected research samples at 60 students (N=60), they were again randomly selected to be divided into two balanced groups. Each of the group formed will contain 30 students (N=30). The two groups will each be called as control and treatment group respectively. The intact sampling method was also employed in this research purposely to ease the process of trainings and supervisions. The subjects for this research have been selected for their active participation in specific sports

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and also considering the total number of contact hours in programmed trainings. Most of these players were placed in the school hostel to alleviate their involvement and the conduction of the training program implementation.

*Instrument.*The instrument applied in this research is the Standing Broad Jump(American Alliance for Health, Physical Education, Recreation and Dance, 1976) to measure the strength of leg muscles. The instrument was chosen because it has high validity (*r*=.607) and high reliability value at 0.963 (Johnson & Nelson, 1986) to test the strength of leg muscles. Findings of a research done by Luebbers et. al. (2003) found that the effect of plyometric training can be measured by the distance of jumping. It can provide the ability of strength of the leg muscles. Apart from that, jumping exercise was selected because the movement is similar with sports movements and relatively at low complexity level (Mc Bride et. al, 2005).

Data Analysis. Data that has been collected was analysed descriptively by using the *Statistical Package for the Social Science for Windows(SPSS version 12.0)* to obtain the means and standard deviations to find out whether there was any significant difference between the pre-test and post-test for both treatment and control groups consisted of soccer players from a sports project school selected by the researchers. Apart from that, inferential analysis of independent t-test was conducted to find out whether both groups are aligned during the pre-test. Paired samples t-test was also utilized to obtain the mean difference between the pre-test and post-test scores in each group. Next, independent t-test was conducted to detect whether there were any significant difference between the control and treatment group for the post-test.

Findings

Independent t-Test on the pre-test scores between the control and treatment groups

Table 1 Comparison of Pre-test Scores between Control and Treatment Groups

Group	Mean	Mean Difference	Standard Deviation	*t*-value	Sig.
Control	5.03	0.00	0.99	1.0	1.0
Treatment	5.03		0.99		

p>0.05, N=30, *df* =58

Table 1 shows the mean scores for control and treatment group pre-tests. No significant difference detected where $p = 1$ ($p > 0.05$). Thus it was safe to assume that both groups were equally balanced.

Paired t-Test on the pre-test and post-test within the control group

Table 2 Comparison between the Pre-test and Post-test in the Control Group

	Mean	Mean Difference	Standard Deviation	*t*-value	Sig.
PreTest	5.03	0.77	0.99	-6.71	0.000*
Post-Test	5.80		1.13		

p<0.05, N=30, *df* =58

Table 2 showed the mean scores for pre-test and post-test within the control group. T-test on the mean difference showed that *t*-value = - 6.71, was significant ($p < 0.05$). The result proved that there was a significant difference between the pre-test and post-test within the control group for muscular strength on legs.

Paired t-Test on the pre-test and post-test within the treatment group

Table 3 Comparison between the Pre-test and Post-test in the Treatment Group

	Mean	Mean Difference	Standard Deviation	*t*-value	Sig.
Pre-Test	5.03	4.54	0.99	-27.60	0.000*
Post-Test	9.57		1.13		

p<0.05, N=30, *df* =58

Table 3 showed the mean scores for pre-test and post-test within the treatment group. T-test on the mean difference showed that *t*-value = - 27.60, was significant ($p < 0.05$). The result proved that there was a significant difference between the pre-test and post-test within the treatment group for muscular strength on legs.

Independent t-Test on the post-test scores between the control and treatment groups

Table 4 Comparison of Post-test Scores between Control and Treatment Groups

Group	Mean	Mean Difference	Standard Deviation	*t*-value	Sig.
Control	5.80	3.77	1.13	-12.73	0.000*
Treatment	9.57		1.17		

P<0.05, N=30, *df* =58

Table 4 shows the mean scores for control and treatment group post-tests. T-test on the mean difference showed that *t*-value = - 12.73, was significant ($p < 0.05$). The result proved that there was a significant difference between the control and treatment groups in the post-test for muscular strength on legs.

Discussions. According to the American College of Sports Medicine (1998), fitness training conducted at least twice per week with high intensity and systematically can increase the power of the leg muscles. In every planned training programme, there are several principles that must be adhered to. To achieve effective results, one of the determining factors is specificity principle. Luebbers et. al. (2003) states that it is necessary for coaches to identify the type of training that is appropriate to achieve threshold for each training session. By controlling this variable, coaches will be able to increase the anaerobic power of athletes. The duration of training programme is also one of the mechanisms in ensuring the effectiveness of the training. According to Luebbers (2003), the duration of training for six weeks and above will enable neuromuscular adaptability to happen. This will provide a good potential in the production of maximum muscular power. Change or performance enhancement is the aim for all coaches. The pattern of regime of training may differ, but the target is always the same. In the context of competition at highest levels, although change after training is small, it will still be important because it can provide a combination that can be manipulated in producing a good result after undergoing a comprehensive training programme (Unger & Wooden, 2000).Specificity is also one of the factors that can influence training where it is able to integrate the components of strength with that of nerve system which controls the motor performance. The pattern in recruiting a certain motor unit may be different depending to the velocity of muscular contraction. Hazeldine (1994) states that the specificity factor refers to the target aimed to be achieved be it for muscle development or certain sports area. This will involve the training or specific movements in building the intended parts or target in a certain area of sports or chosen event. Through the addition of training intensity such as repetitions, it can increase the level of fitness followed by the increment of workloads. By increasing the workloads, muscular strength can be produced effectively. This will encourage the muscles to contract at maximum level, and stimulate adaptability and adaption when doing the tasks. With the addition of workloads, progressive difficulty level will also be increased towards the muscles. Muscles that are experiencing difficulties will increase the strength level to overcome it. When the muscles can overcome the difficulty level, they will be able to undergo the training with the added difficulty (O'Shea, 1976).One of the plyometric training patterns is by utilizing jumping. The intervention of plyometric training is seen as a large effect towards the speed of running at the accelerating phase. Specific principle stressed in this training has shown a magnitude change in the performance of accelerating and produced strength at running phase. The transfer of training to real situation is one of the advantages that is produced through plyometric training. For example, the level of velocity of muscular actions during training is quite similar with the actual event. Thus, the transfer of acceleration and strength from plyometric training can be evident at the acceleration phase while running (Rimmer & Sleivert, 2000).The strength of leg muscles depends on the size and number of muscles. By undergoing plyometric training programme, it can provide positive effects towards production of power and increased size of muscle fibres. The training is also recommended for any type of activity that involves motor movements such as running and jumping. Also, this type of training can produce the number of explosive energy in a short period of time. It will boost the performance of players' strength in any sport involved (Potteiger et. al. 1999). Improvement in the muscle performance followed by plyometric training will increase the process of recruiting the motor unit. The increase in muscular strength is also due to the increase in the size of muscle fibres. This will develop the muscle size to

become bigger (hypertrophy) and simultaneously influence the height of jump (strength of leg muscles) as well as the threshold of power (Potteiger et. al., 1999). Preparation of players must be considered before participating in a real competition. The production of strength at maximum level is critical for every player. This will increase the production of power that can contribute towards the performance of players' strength. Plyometric can be manipulated by weights or difficulties. The effects of plyometric will be more significant if the weights were increased. It can be increased by adding the number of exercises in each set and also the number of sets. The increment of kinetic subjects will be added to outdo the weight or mass of the individual body (Vossen et. al., 2000). By adding the weights, muscles will have to do extra work. The process of concentric and eccentric will assist the performance enhancement of athletes. Plyometric training is a combination of contraction and expansion of muscles where elastic energy storage can be evident in frame muscles. Through power and velocity, each muscle fibre can produce large energy during the expansion as compared to contraction of muscles. The change in the structure of connecting tissues also influences the mechanism during training sessions (Jamurtas et. al., 2000). It is also due to the increment of the size of muscle fibres. The production of muscular strength is related with the development of the size of muscle fibres. Specific plyometric training can focus to a certain muscle and the kind of event to participate. In the preparation of soccer players, the leg muscles play vital roles. The plyometric training programme has similarities in terms of difficulties and aerobic exercises. With the prolonged training periods as well as increase in the number of weights and intensity, adaptability can be constructed (Robinson et. al., 2000). Running and jumping actions as well as continuous leaping in soccer also influenced the success of a team. Plyometric is a type of training that can improve the performance of straight jumping and anaerobic power. When plyometric movements were implemented, muscles will undergo a change phase, from eccentric to concentric. The contraction and expansion process will reduce the time and increase the production of power more than usual. Muscles that stored excess elastic energy and the stimulation of muscle expansion are exploited to enable more tasks to be completed during concentric movement phase (Luebbers, et. al., 2003).According to Reilly et. al. (1993), plyometric training uses muscular expansion and contraction cycle. The regime of this training employs bouncing, jumping and leaping used for special events such as sprints, jumps, gymnastics and other sports involving expansion and contraction of the muscles to produce explosive power. Due to the weight received during training, such acceleration and running action is well suited for a football game. Although the type of individual muscle fibre is genetically determined, the process of training muscles can be done to make them compatible with the desired pattern. This indicates that the production increase on receptor stimulations and increased motor unit activity will happen when undergoing plyometric trainings. With plyometric drills, more motor units will be stimulated and activated. This will extend the period from experiencing lethargy at the threshold level (Mc Laughlin, 2001).In plyometric training, the element of body weight is one form of difficulty. It will force the muscles to perform additional tasks. Difficulty training not only can increase strength and power but also level of flexibility. Besides, increasing muscular abilities can enhance energy and health to prolong life expectancy (Moran & Mc Glyn, 2001). The use of difficulty training method is to increase muscular strength, speed and power to improve sports performance. Since most sports use movements that involve force and velocity, most coaches consider them as an important element especially among strength coaches (Baker et. al., 2001).Strength is a fitness component that must be mastered by athletes in ensuring success in events they participated. The ability to jump is the main contributor towards the success of distance sports such as long jump (Chu, 1988). The effect of jumping exercise towards straight jump is that the height of jump can be increased, through plyometric training. Plyometric drills are the connector for explosive power that enables players to optimize energy production. Hence the combination of plyometric and weight training must be utilized by athletes (Tricoli et. al., 2005). Increasing the ability to jump is the main goal for athletes. With a carefully planned programme, their abilities can be improved from 10% up to 25%. Most of the training methods used provide emphasis on muscles involved for the required skills. According to Myer et. al. (2005), the effect of plyometric training can be improved with the combination of difficulties or increasing additional weights for players who has persistently undergone plyometric training.

Conclusions

The research finding denotes that plyometric is one of the training forms appropriate for strength enhancement. This training must be given focus by coaches, Physical Education teachers, sports teachers and authorities involved in sports programmes because the effectiveness of the training can be proven after six weeks of training. In addition, the use of minimal equipment also enables such training to be applied by all parties where it uses body weight as difficulties. Coaches of other types of sports can also take into account this training because strength is one of the factors in determining effectiveness and quality of individual player. Plyometric training can also be revealed to school students as one of the ways to measure the level of muscular strength on their legs when involved in Physical Education activities in school.

References

Abdullah Ali. (1989). Siri Sukan Popular Fajar Bakti Bola Sepak: Shah Alam Penerbit Fajar Bakti Sdn. Bhd.

Ahtiainen, J.P., Pakarinen, A., Alen, M., Kraemer, W.J. & Hakkinen, K. 2005. Short Vs Long Rest Period Between the Sets in Hypertrophic Resistance Training: Influence on Muscle Strength, Size and Hormonal Adaptations in Trained Men. Journal of Strength and Conditioning Research, 19(1): 33-38.

Alemany, J.A., Pandorf, C.E.,Montain, S.J., Castellani, J.W., Tuckow, A.P. & Nindl, B.C. 2005, Reliability Assessment of Ballistic Jump Squats and Bench Throws. Journal of Strength and Conditioning Research, 19(1): 33-38.

American College of Sports Medicine. 1998. Guidelines for Exercise Testing and Prescription 3rd ed. Baltimore: Williams & Wilkins.

Arslan, C. 2005. Relationship between the 30-Second Wingate Test Characteristics of Isometric and Explosive Leg Strength in Young Subjects. Journal of Strength and Conditioning Research, 19(3): 658-666.

Balanibis, C.P., Psarakis, C.H., Moukas, M., Vassilou, M.P & Behrakis, P.K., 2003, Early Phase Changes by Concurrent Endurance and Strength Training. Journal ofStrength and Conditioning Research, 17(2): 393-401.

Baker, D., Nance, S. & Moore, M., 2001. The Load That Maximizes the Average Mechanical Power Output During Explosive Bench Press Throws in Highly Trained Athletes. Journal of Strength and Conditioning Research, 15(1) : 20-24.

Baker, D. 2001, A Series of Studies on the Training of High Intensity Muscle Power in Rugby League Football Players. Journal of Strength and Conditioning Research, 15(2): 198-209.

Barth & Zampel. 2004, Soccer Training. London: Meyer & Meyer Sport.

Bean, A. 1997.A Complete Guide to Strength Training. London: A&C Black.

Brandenburg, J.P. 2005,The Acute Effect of Prior Dynamic Resistance Exercise Using Different Loads on Subsequent Upper-Body Explosive Performance in Resistance-Trained Man. Journal of Strength and Conditioning Research, 19(2): 427-432.

Bompa, T., 1994. Theory and Methodology of Training: The Key To Athletic Performance 3rd ed. Dubuque: Kendall/ Hunt Publishing Company.

Chu, D. (1998). Jumping Into Plyometric 2nd edit. Illinois: Champaign.

Cronin, J.B. & Hansen, K.T. 2005, Strength and Power Predictors of Sports Speed. Journal of Strength and Conditioning Research, 19(2): 349-356.

Cohen, L., Manion, L. & Morrison, K., 2000, Research Methods in Education 5th ed. London: Routhledge/ Falmer.

Davis, D.S., Bosley, E.E., Keeney, S.A., Rosetti, A.M., Mancinelli, C.A. & Petronis, J.J., 2006, The Relationship of Body Segment Lengthand Vertical Jump Displacement in Recreational Activities. Journal of Strength and Conditioning Research, (20): 136-140.

Deane, R.S., Chow, J.W., Tillman, M.D. & Fournier, K.A. 2005,. Effects of Hip Flexor Training on Sprint, Shuttle Run and Vertical Jump Performance. Journal of Strength and Conditioning Research, 19(3): 615-621.

Flethcer, I.M. & Hartwell, M. 200, Effect of An 8 Week Combined Weights and Plyometrics Training Program on Golf Drive Performance.Journal of Strengthand Conditioning Research. 18(1): 59-62.

Fraenkel, J.R. & Wallen, N.E. 2006. How To Design and Evaluate Research in Education 6th ed. Dubuque IA: McGraw Hill.

Ford, K.R., Myer, G., Smith, R.L., Byrnes, R.N., Dopirak, S.E. & Hewett, T.E. 2005. Use of An Overhead Goal Alters Vertical Jump Performance and Biomechanics. Journal of Strength and Conditioning Research, 19(2):394-399.

Fox, E.L., Mathews, D.K. 1981. ThePhysiological Basic of Physical Education and Athletics. Philadelphia: WB Saunders Co.

Fox, E.L., Bowers, R.W., & Foss, M.L. 1988. The Physiological Basis of Physical Education and Athletics 4th ed.Dubuque, Iowa: Wm.C Brown.

Gehri, J.D. et.al. 1998. A Comparison of Plyometric Training Techniques for Improving Vertical Jump Ability and Energy Production. Journal of Strength and Conditioning Research, 12(2): 85-89.

Gonzalez-Badillo, J.J., Gorostiaga, E.M. & Arellano,R. 2005. Moderate Resistance Training Volume Produces More favourable Strength Gains than High or Low Volumes during Short-Term Training Cycle.Strength and Conditioning Research, 19(3): 689-697.

Halviola, J.H.S., Sallinen, J.M., Kraemer, W.J., Allen, M.J. & Hakkinen, K.K.T. 2006. Effects of Strength Training on Muscle Strength Characteristics, Functional Capabilities, and Balance in Middle-Aged and Older Women. Journal of Strength and Conditioning Research, 20(2): 336-344.

Hazeldine, R., 1994. Strength Training For Sport. Wiltshire, England: The Crowood Press.

Hoffman, J.R., Ratamess, M.A., Cooper, J.J., Kang, J., Chilakos, A. & Faigenbaum, A.D. 2005. Comparison of Loaded and Unloaded Jump Squat on Strength/Power Performance in College Football Players.Strength and ConditioningResearch 19(4): 810-815.

Jamurtas, A. Z., Fatourus, J.G., Buckenmeyer, P., Kokinidis, E., Taxildaris, K., Kambas, A. & Kyriazis, G. 2000. Effect of Plyometric Exercise on Muscle Soreness and Plasma Creatine Kinase Levels and Its Comparison with Eccentric and Concentric Exercise. Journal of Strength and Conditioning Research, 14(1): 68-74.

Johnson, B.L., Nelson, J.K. 1986. Practical Measurement of Evaluation in PhysicalEducation (4th ed). Edine, Minnesota: Burgess Publishing.

Kementerian Pendidikan Malaysia. (1999). Sukatan Pelajaran Pendidikan Jasmani. Kuala Lumpur: Dewan Bahasa dan Pustaka.

Khalid Johari. 2004. Penyelidikan Dalam Pendidikan: Konsep & Prosedur. Petaling Jaya: Prentice Hall.

Kotzamanidis, C. 2006. Effect of Plyometric Training on Running Performance and Vertical Jumping in Prepubertal Boys. Journal of Strength and Conditioning Research, 20(3): 441-445.

Kubo, K., Kanehisa, H. & Fukunaga, T. 2005. Influences of Repetitive Drop Jump and Isometric Leg Press on Tendon Properties in Knee Extensors. Journal of Strength and Conditioning Research, 19(4), 864-870.

Linnamo, V., Pakarinen, A., Komi, P.V., Kraemer, W.J & Hakine, K. 2005. Acute Hormonal Responses to Submaximal and Maximal Heavy Resistance and Explosive Exercises in Men and Women. Strength and Conditioning Research, 19(3), 566-571.

Little, T. & Williams, A.G. 2005. Specificity of Acceleration, Maximum Speed, and Agility in Professional Soccer Players. Journal of Strength and Conditioning Research, 19(1): 76-78.

Luebbers, PA, et. al. 2003. Effects of Plyometrics Training and Recovery on Vertical Jump Performance and Anaerobic Power. Journal of Strength and Conditioning Research, 17 (4), 704-709.

Majid Konting. 1998,. Kaedah Penyelidikan .Kuala Lumpur: DBP.

Mangus, B.C., Takahashi M., Mercer, J.A., Holcomb, W.R., McWhorter, J.W. & Sanchez, R. 2006 Investigation of Vertical Jump Performance After Completing Heavy Squat Exercises. Journal of Strength and Conditioning Research, 20(3): 597-600.

Mc Bride, J.M., Mc Bride, T.T, Davie, A. & Newton, R.U. 2002. The Effect of Heavy vs Light-Load Jump Squats on the Development of Strength, Power and Speed. Journal of Strength and Conditioning Research, 16(1): 75-82.

Mc Bride, J.M., Nimphius, S. & Erickson, T.M. 2005. The Acute Effects of Heavy-Load Squats and Loaded Countermovement Jumps on Sprint Performance. Journal ofStrength and Conditioning Research, 19(4): 893-897.

Mc Curdy, K.W., Langford, G.A., Doscher, M.W., Wiley, L.P., & Mallard, K.G. 2005. The Effect of Short-Term Unilateral and Bilateral Lower-Body Resistance Training. Journal of Strength and Conditioning Research, 15(2): 198-209.

Mc Laughlin. E.J. 2001. A Comparison between Two Training Programs and Their Effects on Fatigue Rates in Women. Journal of Strength and Conditioning Research, 15(1): 25-29.

Moir, G., Sanders, R., Button C., & Glaister, M.,2005. The Influence of Familiarization on the Reliability of Force variables Measured During Unloaded and Loaded Vertical Jumps. Journal of Strength and Conditioning Research, 19(1): 129-134.

Moran, G.T., & Mc Glyn, G. 2001, Dynamic Strength Training and Conditioning 3rd ed. NY: McGraw Hill.

Myer, G.D., Ford, K.R., Palumbo, J.P. & Hewett, T.E. 2005.Neuromuscular Training Improves Performance and Lower-Extremity Biomechanics in Female Athletes. Journal of Strength and Conditioning Research, 19(1): 51-60.

Myer, G.D., Ford, K.R., Brent, J.L., & Hewett, T.E. 2006. The Effect of Plyometric vs. Dynamic Stabilization and Balance Training on Power, Balance and Landing Force in Female Athletes. Journal of Strength and Conditioning Research, 20(2): 345-353.

Newton, R., Rogers, R.U, Volek, J,S., Hakkinen, K. & Kraemer, M.J. 2006. Four weeks of Optimal Load ballistic resistance Training at the End of Season Attenuates Declining Jump Performance of Woman Volleyball Players. Journal ofStrength and Conditioning Research, 20(4): 955-961.

O'Shea, J.P. 1976. Scientific Principles and Methods of Strength Fitness. Massachusetts: Addison-Wesley.

Potteiger, J,A. et al. 1999. Muscle Power and Fibre Characteristics Following 8 Weeks of Plyometric Training. Journal of Strength and Conditioning Research, 13 (3): 275-279.

Radcliff, J.C. & Ferentinos, R.C. 1999. High Powered Plyometrics .USA: United Graphics.

Reilly, T., Clarys, J. & Stribbe, A. (1993). Science and Football II. London: E & FN Spon.

Rimmer, E. & Sleivert,G. 2000. Effect of a Plyometrics Intervention Program on Sprint Performance.Journal of Strength and Conditioning Research. 14(3): 295-30.1

Robinson, L,E., Devor. S,T., Merrick. M, A. & Buckworth, J. 2004. The Effect of Land vs Aquatic Plyometrics on Power, Torque, Velocity and Muscle Soreness in Women. Journal of Strength and Conditioning Research, 18(1): 84-91.

Rosenthal, G. 1994. Soccer Skills and Drills. NY: Fireside.

Saunders, P.U., Telford, R.D., Pyne, D.B., Peltola, E.M., Cunningham, R.B., Gore, C.J. & Hawley, J.A. 2006. Short Term Plyometric Training

Improves Running Economy in Highly Trained Middle and Long Distance Runners.Journal of Strength andConditioning Research, 20(4): 947-954.

Scholich, M. 1992. Circuit Training for All Sports: Methodology of effective fitness training. Toronto: Sports Book Publisher.

Schulte-Edelmann, J.A., Davies, G,J, Kerzonek, T.W. & Gerbeding, E.,D. 2005. The Effect of Plyometric Training of the Posterior Shoulder and Elbow. Journal ofStrength and Conditioning Research, 19(1): 129-134.

Selye, H. 1956. The Stess of Life.NY: McGraw Hill.

Sidek Mohd Noah. (2002). Reka Bentuk Penyelidikan: Falsafah, Teori dan Praktis.Serdang: Penerbit UPM.

Simao, R., Farinatti, P,T,V., Polito, M.D., Maior, A.S. & Fleck,S.2005. Influence of Exercise Order on the Number of Repetitions Performed and Perceived Exertion during Resistance Training. Journal of Strength and Conditioning Research, 19(1): 152-156.

Smilios, A., Pilaindis, T., Sotiropoulos, K., Antonakis, M. & Tokmakidis S.P. 2005. Short Term Effects of Selected Exercise and Load in Contrast Training on Vertical Jump Performance. Journal of Strength and Conditioning Research, 19(1): 135-139.

Sneider.M.M, 2004 Fit 4 Ever: Strength Training. United Kingdom: Meyer & Meyer Sport.

Solonia, M.A. Chu, D.A., Cheifetz, P.M., & Freidhoff, G.C. (2004). Upper Body Power as Measured By Medicine Ball Throw Distance and Its Relationship To Class Level Among 10 and 11 Year Old Female Participants in Club Gymnastics. Journal of Strength and Conditioning Research, 18(4): 695-702.

Thomas, J.R. & Nelson, J.K. 1990. Research Methods in Physical Activity 2nd ed. Champaign Il: Human Kinetics

Tricoli, V., Lamas, L., Carnevale, R. & Ugrinnowitsch C. (2005)Short –Term Effects on Lower Body Functional Power Development: Weightlifting Vs Vertical Jump Training Programs.Journal of Strength and Conditioning Research, 19(2), 433-437.

Ugarkovic, D., Matavulj, D., Kukolj, M. & Jaric, S. 2002. Standard Anthropometrics, Body Composition, and Strength Variables as Predictors of Jumping Performance in Elite Junior Athletes. Journal of Strength and Conditioning Research, 16(2): 227-230.

Unger, C.L.& Wooden, M.J.2000. Effect of Foot Intrinsic Muscle Strength Training on Jumping Performance. Journal of Strength and Conditioning Research, 14(4): 373-378.

Vossen. J,E., Kramer, J.F., Burke, D.G., & Vossen. D. P. 2000. Comparison of Dynamic Push-Up and Plyometric Push-Up Training on Upper Body and Strength. Journal of Strength and Conditioning Research, 14(3): 248-253.

Wilmore, J.H & Costill, D.L. 1988. Training for Sport and Activity: The Physiological Basis of Conditioning 3rd ed. Dubuque, Iowa: Wm.C Brown.

Wilson, J.G, et al. 1996.Strength Diagnosis: The Use of Test Data to determine specific Strength Training. Journal of Sport Science, 14, 167-173.

Wilson, G., Murphy, A., & Giorgi, A. 199. Weight and Pylometric Training: effect on Eccentric and Concentric Force Production. Canadian Journal of Applied Physiology, 21: 301-315.

Weiss, L.W, Fry, A.C., & Relyea, G.E. 2002. Explosive Strength Deficit as a Predictor of Vertical Jumping Performance. Journal of Strength and Conditioning Research, 16(1): 83-86

Woolstenhulme, M.T., Griffith, C.M., Woolstenhulme, E.M. & Parcell, A.C. 2006. Ballistic Strength Increases Flexibility and Acute Vertical Jump Height When Combined With Basketball Activity. Journal of Strength and Conditioning Research, 20(4): 799-803.

Young, W.B., Jenner, A.& Griffith, K. 1998. Acute Enhancement of Power Performance from Heavy Load Squat. Journal of Strength and Conditioning Research, 12: 82-84.

Zatriosky, V. 1995. Science and Practical in Strength Training. Champaign Illinois: Human Kinetics