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Isokinetics Strength and Power of Female Field Hockey Players

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ABSTRACT
Many performances in sports including hockey players need strength and power. The purpose of this study was to investigate the strength and power of female field hockey players. Subjects were 11 female sub-elite field hockey players. Data was obtained from isokinetic strength and power test using a Cybex 340 isokinetic dynamometer. The protocol of the Cybex test involved the measurement of isokinetic strength as peak torque in a slow velocity movement ($60^{o}\cdot sec^{-1}$), and isokinetic power as peak torque in a medium velocity movement ($180^{o}\cdot sec^{-1}$), during knee flexion and extension of both right and left legs. Data were analyzed using mean and standard deviation (X±SD).
The results of this study found that the mean hamstring strength were 88.2±10.6 N·m and 1.4±0.2 $N\cdot m\cdot kg^{-1}$ (left); and 88.5±13.9 N·m and 1.4±0.2 $N\cdot m\cdot kg^{-1}$ (right). Mean quadriceps strength were 152.9±27.0 N·m and 2.4±0.3 $N\cdot m\cdot kg^{-1}$ (left); 152.6±19.2 N·m and 2.4±0.2 $N\cdot m\cdot kg^{-1}$ (right). Mean hamstring power were 58.1±13.8 N·m and 0.9±0.2 $N\cdot m\cdot kg^{-1}$ (left) and 61.3±14.4 N·m and 1.0±0.2 $N\cdot m\cdot kg^{-1}$ (right). Mean quadriceps power were 100.2±12.5 N·m and 1.6±0.2 $N\cdot m\cdot kg^{-1}$ (left); 94.9±13.7 N·m and 1.5±0.2 $N\cdot m\cdot kg^{-1}$ (right). The conclusion of this study was stated that hamstring strength and quadriceps power of the players were lower than elite hockey players, but hamstring power and quadriceps strength were greater than healthy women.

Keywords: *knee, flexion, extension, quadriceps, hamstring*

1. INTRODUCTION

Isokinetic strength and power testing is a common method to analyze not only the strength but also the power of athletes that are set in a laboratory. There has been some research regarding isokinetic strength and power [1, 2, 3]. Isokinetic dynamometer is one of equipment that has been used as a standard research tool to investigate the dynamic muscle function of single muscle groups [4]. There is some movement in field hockey that require high muscle strength from the lower bodies or extremities. The quadriceps muscles have the important role especially for a goalkeeper) in tackling and kicking, while the hamstrings muscles play an important role to control running activities of the players and to stabilize the knee, especially during changes direction. The musculature around the knee is important in the prevention of injuries as well as in the enhancement of knee function [5].

Canadian women's Olympic 1984 field hockey players have a mean peak torque of 1.8±0.3 $N\cdot m\cdot kg^{-1}$ for knee flexion and 2.7±0.4 $N\cdot m\cdot kg^{-1}$ for knee extension [6]. It seems that the hamstring muscles of Canadian female field hockey players were weaker than the quadriceps muscles. The field hockey players require adequate strength in both hamstring and quadriceps muscle groups. It is because strength is very important for the field hockey players due to the large involvement of kicking and tackling (goalkeeper), running, and sprinting during the field hockey game. The purpose of this was to investigate isokinetic strength and power of female sub-elite hockey players.

2. METHODS

This study was conducted on 11 Australian female field hockey players. All players were competing at a sub-elite (club) level of field hockey in Australia. These players included 1 goalkeeper, 2 backs, 3 halves, and 5 forwards, with playing experience ranging from 2 – 13

years. The testing was conducted in the sports science laboratory of the University of Canberra Australia.

Isokinetic strength and power were measured by using a Cybex 340 isokinetic dynamometer (Cybex Corporation, Ronkonkoma, New York). The Cybex dynamometer was calibrated before measurement using the manufacturer's instruction. Subjects warmed up on a cycle ergometer at speed of 75 watts for 5 minutes with a 5-second sprint at the end of each minute, followed by stretching for leg muscles. The protocol for the Cybex test involved the measurement of isokinetic strength as peak torque in a slow velocity movement ($60^{o}\cdot sec^{-1}$), and isokinetic power as peak torque in a medium velocity movement ($180^{o}\cdot sec^{-1}$), during knee flexion and extension of both right and left legs.

The subjects were seated on the Cybex machine and secured by a seat belt that crossed the chest and hips. The leg to be tested was stabilized with a restraint strap above the knee at midthigh and the lateral femoral condyle was aligned with the axis of rotation of the isokinetic dynamometer [7]. The lever arm was attached to the lower leg by a velcro strap superior to the medial malleolus.

Before the test trials at each velocity, subjects performed a short warm-up of four trial repetitions at the velocity of that test with 20 seconds rest. Then, subjects performed three test repetitions of maximal knee flexion and extension at each velocity. The subject performed each test repetition as fast and as hard as possible in both directions. Subjects were verbally encouraged during the test. The strength and power of the quadriceps and hamstrings (N·m and ($N\cdot m\cdot kg^{-1}$), and hamstrings/quadriceps ratio (%) were recorded. The TEM [8] values for this test, determined previously on a separate group of similar subjects were 6.0N·m and 7.9N·m for the left and right hamstring; and 14.2N·m and 19.9N·m for the left and right quadriceps, respectively. Data were analyzed using mean±standard deviation (X±SD).

3. RESULTS

The weighted mean values for isokinetic strength and power test results for female field hockey players were presented in Table 1.

Table 1. The weighted mean values for isokinetic strength and power of the players.

Testing	X±SD	Range
Isokinetic Strength:		
- Left hamstring (N·m)	88.2±10.6	75 – 104
- Right hamstring ($N\cdot m\cdot kg^{-1}$)	88.5±13.9	72 – 121
- Left quadriceps (N·m)	152.9±27.0	118 – 193
- Right quadriceps ($N\cdot m\cdot kg^{-1}$)	152.6±19.2	129 – 191
- Left hamstring/quadriceps ratio (%)	58.6±6.9	48 – 73
- Right hamstring/quadriceps ratio (%)	57.9±5.3	50 - 66
Isokinetic Power:		
- Left hamstring (N·m)	58.1±13.8	35 – 79
- Right hamstring ($N\cdot m\cdot kg^{-1}$)	61.3±14.4	42 – 95
- Left quadriceps (N·m)	100.2±12.5	83 – 118
- Right quadriceps ($N\cdot m\cdot kg^{-1}$)	94.9±13.7	76 – 115
- Left hamstring/quadriceps ratio (%)	59.8±9.8	33 – 69
- Right hamstring/quadriceps ratio (%)	62.0±12.2	44 -82

Table 1 showed that the mean value for hamstring strength (N·m) of the players in this study was 88.2±10.6 N·m with a range of 75 to 104 N·m (for left hamstring) and 88.5±13.9 N·m with a range of 72 to 121 N·m (for right hamstring). The mean value for hamstring strength ($N\cdot m\cdot kg^{-1}$) of female field hockey players was 1.4±0.2 $N\cdot m\cdot kg^{-1}$ with a range of 1.1 to 1.6 $N\cdot m\cdot kg^{-1}$ (for left hamstring) and 1.4±0.2 $N\cdot m\cdot kg^{-1}$ with a range of 1.2 to 1.7 $N\cdot m\cdot kg^{-1}$ (for right hamstring).

The mean value for quadriceps strength (N·m) for female field hockey players was 152.9±27.0 N·m with a range of 118 to 193 N·m (for left quadriceps) and 152.6±19.2 N·m with a range of 129 to 191 N·m (for right quadriceps). The mean value for quadriceps strength ($N\cdot m\cdot kg^{-1}$) of the players was 2.4±0.3 $N\cdot m\cdot kg^{-1}$ with a range of 1.8 to 2.8 $N\cdot m\cdot kg^{-1}$ (for left quadriceps) and 2.4±0.2 $N\cdot m\cdot kg^{-1}$ with a range of 2.0 to 2.6 $N\cdot m\cdot kg^{-1}$ (for right quadriceps). The mean value for hamstring/quadriceps ratio during the strength test ($60^{o}\cdot sec^{-1}$) was 58.6±9.8% with a range of 48 to 73% (left) and 57.9±5.3% with a range of 50 to 66% (right).

The mean value for hamstring power (N·m) of the Australian female field hockey players was 58.1±13.8 N·m with a range of 35 to 79 N·m (for left hamstring)

and 61.3±14.4 N·m with a range of 42 to 95 N·m (for right hamstring). The mean value for hamstring power ($N \cdot m \cdot kg^{-1}$) of the Australian female field hockey players was 0.9±0.2 $N \cdot m \cdot kg^{-1}$ with a range of 0.6 to 1.3 $N \cdot m \cdot kg^{-1}$ (for left hamstring) and 1.0±0.2 $N \cdot m \cdot kg^{-1}$ with a range of 0.7 to 1.3 $N \cdot m \cdot kg^{-1}$ (for right hamstring).

The mean value for quadriceps power (N·m) of the Australian female field hockey players was 100.2±12.5 N·m with a range of 83 to 118 N·m (for left quadriceps) and 94.9±13.7 N·m with a range of 76 to 115 N·m (for right quadriceps). The mean value for quadriceps power ($N \cdot m \cdot kg^{-1}$) of the Australian female field hockey players was 1.6±0.2 $N \cdot m \cdot kg^{-1}$ with a range of 1.3 to 1.8 $N \cdot m \cdot kg^{-1}$ (for left quadriceps) and 1.5±0.2 $N \cdot m \cdot kg^{-1}$ with a range of 1.2 to 1.8 $N \cdot m \cdot kg^{-1}$ (for right quadriceps). The mean value for hamstring/quadriceps ratio during the power test ($180^{o} \cdot sec^{-1}$) was 59.8±9.8% with a range of 33 to 60% (left) and 62.0±12.2% with a range of 44 to 82% (right).

4. DISCUSSION

Table 1 indicated that there was no imbalance between left and right hamstring strength scores (N·m) for these athletes. The right hamstring muscles were slightly stronger than the left hamstring. The mean hamstring strength ($N \cdot m \cdot kg^{-1}$) of the players was lower than the 1984 Canadian women's Olympic field hockey team [7] (Ready and Merwe, 1986). Hamstring strength is extremely important for players for joint stabilization during various tasks, notably in eccentric action [7] (Cometti et al, 2001). Hamstring muscles are very important for the athletes to control the activities during the games such as running and changing direction.

In addition, there was no imbalance in quadriceps strength (N·m) of the players between right and left muscles. The left quadriceps was slightly greater than the right quadriceps. The mean quadriceps strength ($N \cdot m \cdot kg^{-1}$) of the players was greater than the 1984 Canadian women's Olympic field hockey team [6]. The quadriceps muscles have an important role for field hockey players especially for kicking (goalkeeper) and tackling.

The female field hockey players had a lower hamstring/quadriceps ratio for the strength test compared to female elite basketball players who were reported to have a mean hamstring/quadriceps ratio during the strength test of 61.9% (left) and 61.6 (right) [9]. These players did not meet the accepted functional requirement for the hamstring/quadriceps ratio (>60%) as a safe guideline for injury prevention [9]. This arose because of relatively low strength in the hamstring muscle group and identifies a possible area for future strength training.

The mean values for hamstring power were higher than healthy women (approximately 55 N·m) [7]. The value of hamstring power (N·m) indicated that there was no imbalance between left and right hamstring power scores for these athletes. The mean value for hamstring power of the players was lower than healthy females who were involved in moderate recreational activity but had no competitive sporting background (119.8 N·m) [10].

The mean value of quadriceps power ($N \cdot m \cdot kg^{-1}$) also indicated that there was no imbalance between right and left quadriceps power scores for the female field hockey players. The mean values of hamstring/quadriceps ratio were lower than the minimum desirable value for hamstring/quadriceps ratio (>70%) during the power test [11].

Field hockey games that involve short and more intense running periods require an equal proportions of energy system not only aerobic but also anaerobic energy systems [12]. Field hockey players need some activities that use an anaerobic energy system for having better performance. Therefore, ATP PC (Adenosine Triphosphate Phosphocreatine) and anaerobic glycolytic pathways can support players' movement that involved some explosiveness such as sprinting, changing direction, jumping (goalkeeper), and tackling. Some hockey activities demand a great deal to accelerate thrusting off with legs muscles in sudden bursts of running and tackling, therefore, power in both of the hips and limps are very important to support hockey players' activities [13].

Isokinetic strength and power of quadriceps and hamstring of the players were lower than Canadian female field hockey players for Olympic 1984, it is perhaps due to the comparison values being obtained on elite-level female field hockey players compared to female field hockey players at a sub-elite level.

5. CONCLUSION

The conclusion of this study can be said that hamstring strength and quadriceps power of the players were lower than elite female hockey players. On the other hand, the hamstring power and quadriceps strength of the players were greater than healthy women.

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REFERENCES

[1] Ayala, F., Croix, M.D.S., Baranda, P.S. & Santoja, F. (2015). Acute effect of two different stretching techniques on isokinetic strength and power. *Rev Andal Med Deporte*. 8(3), 93-102.

[2] Cometti, G., Maffiuletti, N.A., Pousson, M., Chafard, J.C. & Maffulli, N. (2001). Isokinetic strength and anaerobic power of elite, sub-elite, and amateur soccer players. *International Journal of Sports Medicine*. 22, 45-51.

[3] Neder, J.A., Nery, L.E., Shizanto, G.T., Andrade, M.S., Peres, C. & Silva, A.C. (1999). Reference values for concentric knee isokinetic strength and power in nonathletic men and women from 20 to 80 years old. *Journal of Orthopaedic & Sports Physical Therapy*. 29 (2), 116-126.

[4] Kusnanik, N.W. (2001). A Comparison of Field and Laboratory Testing of Sports Specific Fitness for Female Field Hockey Players. (Unpublished Master's thesis, University of Canberra) Faculty of Applied Science. Australia.

[5] Zakas, A., Mandroukas, K., Vamvakoudis, E., Christoulas, K. & Agglopoulou, N. (1995). Peak Torque of Quadriceps and Hamstring Muscles in Basketball and Soccer Players of Different Divisions. *Journal of Sports Medicine and Physical Fitness*. Vol.35, 199-205.

[6] Ready, A.E. & Merwe, M. (1986). Physiological Monitoring of the 1984 Candian Womens' Olympic Field Hockey Team. *The Australian Journal of Science and Medicine in Sports*. 18 (3), 13-18.

[7] Dibrezzo, R., Fort, I.L. & Brown, B. (1991). Relationships among Strength, Endurance, Weight and Body Fat during Three Phases of the Menstrual Cycle, *Journal of Sports Medicine and Physical Fitness*, 31, 89-94.

[8] Hopkins, W.G. (2001). A New View of Statistics, www.sportsci.ORG/resource/stats/precision/html.

[9] Connoly, D.A.J., Loomis, S. & Teplick. J. (1991). Quadriceps - Hamstring Ratio is Low in Selected Elite Female Athletes, *Medicine and Science in Sports and Exercise*, 30 (5), S36.

[10] Rizzardo, M. & Bay, G. (1988). Eccentric and Concentric Torque and Power of the Knee Extensors of Females. *Canadian Journal of Sports Science*. 13 (2), 166-169.

[11] University of Canberra. (2000). Physiology of Exercise Laboratory Manual. The University of Canberra. Australia.

[12] Kusnanik, N.W., Rahayu, Y.S. & and Rattray, B. (2018). Physiological Demands of Playing Field Hockey Game at Sub Elite Players. *IOP Conference Series: Materials Science and Engineering*. Vol. 288.

[13] Kusnanik, N.W. & Hartati, H. (2017). Physical and Physiological Profile of Junior High Students in Indonesia, *Sport Science*. 10 (1), 96-99. [9] A. Pnueli, In the transition from global to modular temporal reasoning about programs, in: K.R. Apt (Ed.), Logics and Models of Concurrent Systems, Springer, Berlin, Heidelberg, 1984, pp. 123–144. DOI: https://doi.org/10.1007/978-3-642-82453-1_5

[14] B. Meyer, Applying "Design by Contract", Computer 25(10) (1992) 40–51. DOI: https://doi.org/10.1109/2.161279

[15] S. Bensalem, M. Bogza, A. Legay, T.H. Nguyen, J. Sifakis, R. Yan, Incremental component-based construction and verification using invariants, in Proceedings of the Conference on Formal Methods in Computer-Aided Design (FMCAD), IEEE Press, Piscataway, NJ, 2010, pp. 257–256.

[16] H. Barringer, C.S. Pasareanu, D. Giannakopolou, Proof rules for automated compositional verification through learning, in Proc. of the 2nd International Workshop on Specification and Verification of Component-Based Systems, 2003.

[17] M.G. Bobaru, C.S. Pasareanu, D. Giannakopoulou, Automated assume-guarantee reasoning by abstraction refinement, in: A. Gupta, S. Malik (Eds.), Proceedings of the Computer Aided Verification, Springer, Berlin, Heidelberg, 2008, pp. 135–148. DOI: https://doi.org/10.1007/978-3-540-70545-1_14