International Journal of Physical Education, Sports and Health 2020; 7(2): 218-220

P-ISSN: 2394-1685
E-ISSN: 2394-1693
Impact Factor (ISRA): 5.38
IJPESH 2020; 7(2): 218-220

www.kheljournal.com
Received: 24-01-2020
Accepted: 26-02-2020

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Comparative analysis of isometric maximum voluntary contraction of knee extensors among different angles

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Abstract
The present study was aimed at comparative analysis of isometric contraction (eccentric) of knee extensors among different angle. The study was conducted on 18 male from Hockey Match Practice LNIPE, Gwalior age ranging from 23-30 with mean and SD of age 26±2.1 years, 173.56±6.00 cm and 68.56± 5.46 kg (as data were normally distributed). Data were collected on isometric maximum voluntary contraction (MVC) of knee extensors in 60º, 90º and 120º angle with the help of Humac Norm isokinetic dynamometer. All the subjects were tested repeatedly on isometric contraction (eccentric) of knee first in 60º, 90º and 120º. The test was consisted of 5 seconds maximum voluntary contraction for 5 reps in each angle. It was hypothesized that there would be significant difference of among different angles on peak torque, average torque, peak torque slope. One-way repeated measure ANOVA was employed for the analysis of result at 5% level of significance. Finally, significant difference ($p>0.05$) was found in peak torque among different angles. Peak torque was found significantly higher ($p>0.05$) in 60º (105.80±13.69 N-m) than 90º (89.87±13.52 N-m) and 120º (75.07±12.08 N-m).Thus, it can be concluded that Maximum Voluntary Contraction (MVC) or peak torque varies in different angle of knee extensors due to force- muscle length (F-L) relationship and the muscle fibres involvement.

Keywords: Isometric maximum voluntary contraction, peak torque, muscles movement arm

Introduction
Strength has been expressed in a variety of ways, including maximum weight lifted (Andrej, K., Nejc, S. 2014, Gross *et al*., 1998) [1], angle-specific maximum isometric torque (Janet, P. L., Susan, G. 1992; Hughes *et al*., 1996; Pavol *et al*., 2002) [6], angle-specific maximum isokinetic torque (JL Vanhee, *et al*. 1997) [13]. Isometric muscle strength includes the assessment of maximal voluntary contraction (MVC). Voluntary muscle strength is a fundamental component of human physical capabilities which can be measured in the form of maximum voluntary torque or peak torque where muscle action is strongest at a single joint angle and angular velocity (Anderson E. *et al*., 2007) [2]. The Maximum voluntary joint torque changes substantially with joint position and velocity because of muscle force–length (F-L) relationship (Sale *et al*., 1982).
These isometric maximum voluntary strength and isokinetic torque are measured using isokinetic dynamometry which has been introduced in the late 1960s for rehabilitation purpose and to investigate the muscle functions of single muscle group. Muscle torque indicates the strength of the action of direction of rotation of the joint which can be estimated by the product of the muscle force (Newtons) and the muscle's associated moment arm length (centimetres) and activated by the nervous system (Donald A. Nicola A. M., Mario B., *et al*. (2007) [4, 10].
Our Body movements usually involve entire pelvic girdle, hip and knee joints *in walking, running, squats and different weight bearing exercises etc.* The primary quadriceps femoris muscle group (rectus femoris, vastus lateralis, vastus medius, and vastus intermedius) causing knee extension from 0-180º range of motion. Several studies revealed that the quadriceps and hamstring muscles strength during various angle of hip extension and flexion (Mandy KY C., Alfred Y.S., *et al*. (2017) [7]. The present study has investigated the isometric maximum voluntary contraction of knee extensors muscles (rectus femoris, vastus lateralis, vastus medius, and vastus intermedius) at different joint angles of knee extension. It was hypotheiszed that there would be significant differences between different angles of knee extensors.

Methods and materials

Selection of subjects

For the purpose of the study 15 healthy active male athlete of Hockey Senior National Level were selected from LNIPE, Gwalior aged ranges from 23-28 with mean and SD of age, height and weight respectively 26±2.1 years, 173.56±6.00 cm and 68.56± 5.46 kg.

Design of the study

Recording were made on the subjects repeatedly on isometric concentric maximum voluntary contraction (MVC) of hip flexion first in 60º, 90º and 120^0.

Variables measures

Peak torque or maximum voluntary contraction (MVC), average torque and peak torque slope (fatigue) were analysed in 60, 90 and 120 of knee extensors with the help of humac norms isokinetic dynamometer.

Testing protocol

Isometric concentric maximum voluntary contraction (MVC) test was consisted of 5 sec maximum voluntary contraction in eccentric contraction with 5 reps at each angle (60º, 90º and 120º) (Brown, Lee E, 2001).

Administration of the test

The subjects were asked to sit down on the back on the chair of humac norms machine with A-Z all manual setting (according to individual) of knee flexion and extension (sitting). Then the subjects were instructed to give maximum effort and were verbally motivated throughout the protocol to contract their dominant leg first at 60º angle than 90º and 120º of knee extension. Straps were applied across the chest to minimize extraneous body movements during thigh muscle contractions, pelvis and mid-thigh. The alignment between the dynamometer rotational axis and the knee joint rotation axis was checked at the beginning of each trial. Subjects are contracted maximally for 5 secs in each repetition total 5 reps in each angle. 5 sec rest were given between each reps.

Statistical analysis

One-way ANOVA with repeated measured designed was employed for the analysis of the results at 5% level of significance as the same subjects were tested repeatedly.

Results

One-way repeated measure ANOVA was employed at 0.05 to compare the mean among different angle (60º, 90^0 and 120^0) of knee extension. Data of all the three groups were normally distributed ($p>0.05$) tested in Mauchly test with SPSS 20. Significant differences ($p<0.000$) was shown in peak torque with F-value 52.67 (Sphericity assumed) among different angle of knee flexors. Peak torque was found significantly higher ($p<0.05$) in 60º (105.80±13.69 N-m) than 90º (89.87±13.52 N-m) and 120º (75.07±12.08 N-m) shown in table no.1 and 2 (mean compared with Bonferroni test).

Table 1: descriptive statistics of peak torque at different angles

Angle of hip flexion	Mean	Std. Deviation	N
Peak torque 60	105.80	13.69	15
Peak torque 90	89.87	13.52	15
Peak torque 120	75.07	12.08	15

Table 2: significance test of angle differences

Source		df	F	Sig.	Partial Eta Squared	Observed Power[a]
Angle	Sphericity Assumed	2	52.67	.000	.79	1.00
	Greenhouse-Geisser	1.296	52.67	.000	.79	1.00
	Huynh-Feldt	1.373	52.67	.000	.79	1.00
	Lower-bound	1.000	52.67	.000	.79	1.00
a.Computed using alpha = .05						

Table 3: Pairwise Comparisons of peak torque in different angle of knee flexors

(I) angle	(J) angle	Mean Difference (I-J)	Std. Error	Sig.[a]
1 (60)	2 (90)	18.933*	4.268	.002
	3 (120)	32.800*	2.669	.001
2 (90)	1 (60)	-18.933*	4.268	.002
	3 (120)	13.867*	2.480	.000
3 (120)	1 (60)	-32.800*	2.669	.001
	2 (90)	-13.867*	2.480	.000
*The mean difference is significant at the .05 level.				

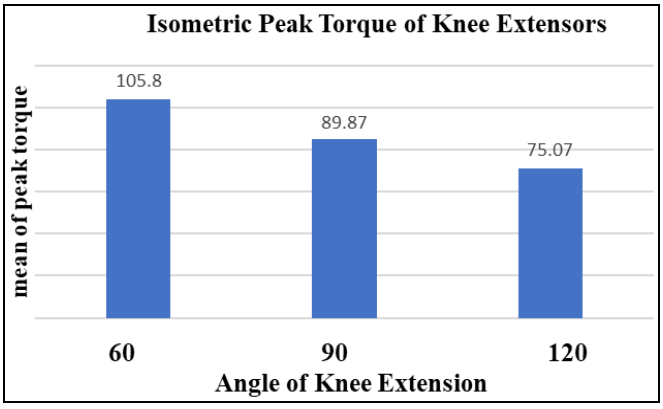

Fig 1: Mean of isometric peak torque at different angle of knee extension

Findings and discussions

Isometric peak torque of knee extensors were found highest in 60º than 90º and 120º angle of knee extension movement the results could be attributed to two main facts that the variation of moment arm length with angle (Ito *et al*., 2000; Maganaris, 2001; Krevolin *et al*., 2004) [10, 11]. and the muscle F–L relation, as muscle length depends on joint angle. The active muscle force peaks at an optimal sarcomere length. The force decreased to zero at maximum and minimum length of muscles fibers (Gordon *et al*., 1966; Winter, 2005) [16]. Deviations between the highest and the lowest torque differences during extension movements might be a result of different knee muscles activation at different angles. Quadriceps group of muscle originates from the lumbar spine and mainly responsible for final torque in whole range of

motion of knee extension at different angles.

Sarcomere produces maximum force when the sarcomere length is *optimum* (Chow, J.W., Darling, W.G. (1999) [3]. Less force is produced if the sarcomere is too short and the overlap is not ideal, as force increases with length increases. The overlap is also not ideal if the sarcomere is too long, producing less force. In this study, at 0^0 torque is minimum due to greater length of muscle. At 60^o - 90^o torque is maximum and higher than 120^o due to optimum length of quadriceps group of muscles. Again, peak torque is decreased at 120^o (muscle length is shortened) during knee extension. The other factors included for angle specific peak torque are fibre length, regional muscle size, tendon stiffness and neural activation (Teddy, M., Gregory, W. K., *et al*. (2001) [14].

Conclusion

The present study show that isometric peak torque is highest in 60^o followed by 90^0. So, it may be concluded that angle specific isometric peak torque of hip flexors varies with different angle of hip joint during hip flexion due to force-muscle length (F-L) relationship, neural drive and regional muscle involvement.

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