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Kinematic analysis of hamstring curl exercise for lower extremities with 15 RM load

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Abstract

The aim of this study was to describe kinematically the hamstring curl exercise (HCE) for lower extremities with fifteen repetitions maximum (15 RM) load. The delimited variables were temporal variables and angle variables of HCE. The study was conducted on ten subjects (five male and five female), weight of the subject was 68.1 ± 14.98 kilogram and age ranged from 17 to 25 years. Each subject had performed HCE with 15 RM load for 15 repetition. Data was collected using two dimensional digital video recording systems for 2D analysis (Kinovea 0.8.21). Collected data was computed with mean, standard deviation, coefficient of variance and analysis of variance. The selected variables for the study were Maximum Knee Flexion Repetition Wise (MKFR), Maximum Knee Extension Repetition Wise (MKER), Time Taken for Downward Movement Repetition Wise (TTDMR), Time Taken for Upward Movement Repetition Wise (TTUMR) and Total Time Taken Repetition Wise (TTTR). Analysis of variance (i.e. comparison among the repetitions) of HCE variables namely MKFRM ($F=0.425$), MKERM ($F=0.155$), TTDMRM ($F=1.154$), TTUMRM ($F=0.705$), TTTRM ($F=0.594$), MKFRF ($F=0.176$), MKERF ($F=0.479$), TTDMRF ($F=0.328$), TTUMRF ($F=0.263$) and TTTRF ($F=0.165$) were statistically insignificant at 0.05 level. In the conducted study the coefficient of variance (C.V.) equal to or more than ten percent considered as heterogeneous otherwise homogeneous. The coefficient of variance (C.V.) that is comparison among the players of each repetitions independently reflected homogeneity in respect to variable namely MKER but heterogeneity for the remaining variables namely MKFR, TTDMR, TTUMR, and TTTR. It is concluded that HCE are consistent for 15 repetitions. The comparison (C.V.) among the players demonstrated homogeneity in regard to angle variable namely MKER (C.V. =7.45%) but heterogeneity for the remaining angle and temporal variables namely MKFR (C.V. =13.04%), TTDMR (C.V. =42.03%), TTUMR (C.V. =42.05%), and TTTR (C.V. =39.06%).

Keywords: Kinematic; Hamstring Curl Exercise; Lower Extremities; Repetition Maximum

1. Introduction

Exercise is physical activity that is planned, structured and repetitive for the purpose of conditioning any part of the body. Exercise is used to improve health, maintain fitness and is important as a means of physical rehabilitation ^[1].

1.1 Hamstring Curl



Biceps Femoris
Semitendinosus
Semimembranosus

Fig 1: Muscles of HCE.

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The hamstring curl is an exercise that strengthens the hamstrings. The hamstrings consist of a group of muscles that run down the back side of the upper leg. Together, they work to flex or bend the knee joint and to extend the hip joint. It is important to adequately develop hamstrings, as they are susceptible to injuries during sports and other physical activities if an individual have lack of strength in hamstrings [2]. There are many more studies have been conducted in the same directions for instance as references Hardin and Holmes, [3] 2017; Peter Stanton, [4] e.t al., 1989. Hamstrings play a key role in knee flexion and hip extension movement, they are pretty much essential for the running motion. Knee flexion and hip extension are also key in movements such as jumping, kicking, skipping and more (Erickson and Sherry, [5] 2017). The hamstrings are important for sporting performance, particularly during high-speed running and sprinting (Morin, [6] et. al., 2015; Higashihara, [7] et. al., 2010; Kyrolainen, [8] et. al., 2005; and many more). There are numerous studies which included hamstring curl exercise (HCE)/leg curl exercise (Fajardo, [9] et. al., 2006; Gallucci and Challis, [10] 2002; Cannell, [11] et. al., 2001; Wright, [12] et. al., 1999 and many more). However an analysis or kinematic description of HCE is missing in India.

The main muscles of HCE are hamstring muscle (Fig.1), the hamstring is actually comprised of three muscles. The semitendinosus (located on the medial part of the thigh),

semimembranosus (located on the medial part of the thigh) and biceps femoris (short and long head) located on the lateral part of the thigh, all play vital roles in movements such as squats, walking, running and essentially any lower body movements, these are the muscles that bend the knee during movements.

1.2 Steps to Perform Hamstring Curl Exercise (Fig. 2)

Step (1) Adjust the machine lever to fit athlete's height and sit on the machine with his back against the back support pad.

Step (2) Place the back of lower leg on top of padded lever (just a few inches under the calves) and secure the lap pad against thighs, just above the knees.

Step (3) Then athlete is required to grasp the side handles on the machine and ensure that the legs are fully straight right in front. This will be his starting position.

Step (4) As athlete exhales, pull the machine lever as far as possible to the back of his thighs by flexing at the knees. Keep athlete's torso stationary at all times. Hold the contracted position for a second.

Step (5) Slowly return to the starting position as he breathes in.

Caution: Using swinging and jerking as you can risk both lower back injury and also a hamstring tear [13].



Fig 2: Demonstration of Hamstring Curl Exercise

The hamstring curl machine is a piece of exercise and fitness equipment that is meant to target and work out the hamstrings and the legs [14]. In this study, seated cybex VR1 leg extension / leg curl machine is used (Fig. 3). Cybex is known for

strength training equipment and free weight systems that are engineered to produce faster fitness results with minimal stress on joints [15].



Fig 3: Cybex VR1 Hamstring Curl Machine.

1.3 Specifications of Cybex VR1 Leg Extension / Leg Curl Machine

Product Number : 13265
 Dimensions (L × W × H) : 68" × 41" × 62" (174 cm × 104 cm × 157 cm)
 Light Stack : 100 lbs (45 kg)
 Standard Stack : 145 lbs (66 kg)
 Light Weight : 419 lbs (190 kg)
 Standard Weight : 464 lbs (211 kg)

1.4 Fifteen Repetition Maximum (15 RM)

In this study, 15 repetition maximum (15 RM) was considered as this type of load develop both strength and endurance, hence appropriate for fitness region for most types of games and sports. 15 RM develops strength, hypertrophy and muscular endurance specifically power endurance. Importance of power endurance evident in athletes of baseball pitchers, sprinters, 50-m freestyle swimmers, martial artists, wrestlers, fencers, tennis players and so on, these athletes must produce powerful movements and repeat them several times with little or no rest. In order to maintain the same amount of power thus certain level of power endurance is required for each athlete. Power endurance is typically characterized by intense, repeated efforts for a relatively short period of time (less than 30 seconds) [16].

The results of this study will help primarily in further understanding the world’s most renowned lower extremities exercise that is hamstring curl and moreover this study was done on Indian intervarsity players so this will also serve as a foundation for further studies on Indians. The dual objective

of this study is to provide kinematic description of hamstring curl using temporal and angle variables.

2. Methodology

Ten (10) healthy intervarsity sportsperson engaged in different sports were randomly selected as subjects for the study. The inclusion criteria for the study was subjects with age ranged from 17 to 25 years and with at least intervarsity level sports participation as their achievement. The sample consists of five male and five female. The weight of the subjects was 68.1±14.98 kilogram. The exclusion criterion for the subjects was those sportsperson who suffered a knee injury in past or showed symptoms of discomfort in knee during performance of HCE. Each subject had performed HCE with 15 RM load for 15 repetition and was recorded with a digital video camera using two dimensional methods independently. Before participating in the study each participant was explained about the proper technique of HCE to be followed. 15 RM was determined by using trial and error method for each subject independently. The video data was analyzed for selected variables using KINOVEA 0.8.21 software for 2D analysis. Hip joint, knee joint and ankle joint were marked for measuring angles of flexion and extension of knee joint. Total time taken to perform each repetition was taken in seconds, time for each repetition were recorded in different clocks. Angle of flexion and extension movement of knee joint of each repetition was measured and recorded. The measurements of the selected variable in HCE namely angle variables and temporal variables are described following (Fig. 4).



Fig 4: Pictorial Presentation of HCE.

Table 1: Abbreviations of Selected Variables.

S. No.	Abbreviation	Variables
1.	MKFR	Maximum Knee Flexion Repetition Wise
2.	MKER	Maximum Knee Extension Repetition Wise
3.	TTDMR	Time Taken For Downward Movement Repetition Wise
4.	TTUMR	Time Taken For Upward Movement Repetition Wise
5.	TTTR	Total Time Taken Repetition Wise

3. Statistical Analysis

For statistical analysis mean, standard deviation and coefficient of variance [in the conducted study the coefficient of variance (C.V.) equal to or more than ten percent considered as heterogeneous otherwise homogeneous], one way analysis of variance were computed, hypothesis was tested at 0.05 level of significance.

4. Findings

Table 2: Kinematic Description of HCE.

S. No	Variables	Repetitions				
		1	2	3	4	5
		M±SD	M±SD	M±SD	M±SD	M±SD
1	MKFR	81.7±12.67	78.7±13.69	79.6±10.45	78.6±10.34	79.7±10.50
2	MKER	154.4±12.52	156.6±12.22	156.4±11.07	155.2±10.94	155.6±10.41
3	TTDMR	1.48±0.41	1.24±0.57	1.33±0.53	1.22±0.48	1.11±0.44
4	TTUMR	1.41±0.62	1.24±0.54	1.62±0.66	1.54±0.63	1.38±0.45

5	TTTR	2.82±0.89	2.48±1.04	2.85±1.03	2.79±1.04	2.43±0.75
Repetitions						
S. No	Variables	6	7	8	9	10
		M±SD	M±SD	M±SD	M±SD	M±SD
1	MKFR	78.4±10.23	77.8±9.38	79.5±11.21	78.8±9.91	78.8±10.02
2	MKER	155.3±10.99	154.1±11.71	153.5±11.25	150.3±10.91	153.9±10.25
3	TTDMR	1.14±0.50	1.14±0.49	1.12±0.52	1.13±0.46	1.14±0.54
4	TTUMR	1.49±0.59	1.45±0.60	1.46±0.77	1.48±0.53	1.52±0.71
5	TTTR	2.60±1.05	2.51±0.92	2.51±1.19	2.57±0.91	2.60±1.18
Repetitions						
S. No	Variables	11	12	13	14	15
		M±SD	M±SD	M±SD	M±SD	M±SD
1	MKFR	78.7±8.65	80.3±9.44	80.1±10.16	80.1±8.50	81.4±10.40
2	MKER	154.7±11.10	154.2±13.14	153.3±13.70	154.1±13.91	159.8±9.67
3	TTDMR	1.16±0.58	1.09±0.40	1.24±0.83	1.04±0.30	1.17±0.39
4	TTUMR	1.55±0.68	1.65±0.88	1.46±0.53	1.57±0.63	1.95±0.81
5	TTTR	2.65±1.20	2.69±1.25	2.68±1.14	2.57±0.83	3.08±1.12
S. No	Variables		M	S.D	C.V.	
1	MKFR	∑∑	79.48	1.36	1.71	
2	MKER	∑∑	155.09	1.26	0.81	
3	TTDMR	∑∑	1.18	0.12	9.93	
4	TTUMR	∑∑	1.53	0.11	7.49	
5	TTTR	∑∑	2.65	0.15	5.57	

Note: N = 10, MKFR and MKER measurements in degree, TTDMR, TTUMR and TTTR measurements in seconds. MKFR = Maximum Knee Flexion Repetition Wise, MKER = Maximum Knee Extension Repetition Wise, TTDMR = Time Taken For Downward Movement Repetition Wise, TTUMR = Time Taken For Upward Movement Repetition Wise, TTTR = Total Time Taken Repetition Wise S.D. = Standard Deviation, M = Mean, C.V. = Coefficient of Variance and ∑∑ = Grand Mean, Standard Deviation and Coefficient of Variance.

According to the finding of table 2, the kinematic description (variables) of HCE namely MKFR, MKER, TTDMR, TTUMR and TTTR demonstrated and irregular trends following the repetitions. The grand mean and standard deviation of 15 repetitions of the variables namely MKFR reported mean and standard deviation 79.48 ± 1.36 with C.V. 1.71, MKER reported mean and standard deviation 155.09 ± 1.26 with C.V. 0.81, TTDMR reported mean and standard deviation 1.18 ± 0.12 with C.V. 9.93, TTUMR reported mean

and standard deviation 1.53 ± 0.11 with C.V. 7.49 and TTTR reported mean and standard deviation 2.65 ± 0.15 with C.V. 5.57 which suggest that repetitions are homogenous in regard to above variables. It has been observed that the C.V. ranged from 0.81 to 9.93, further highest was observed in the variable namely TTDMR followed by TTUMR, TTTR, MKFR and the least was MKER. It is concluded that kinematic description of HCE are homogenous for 15 repetitions in respect to each selected variables.

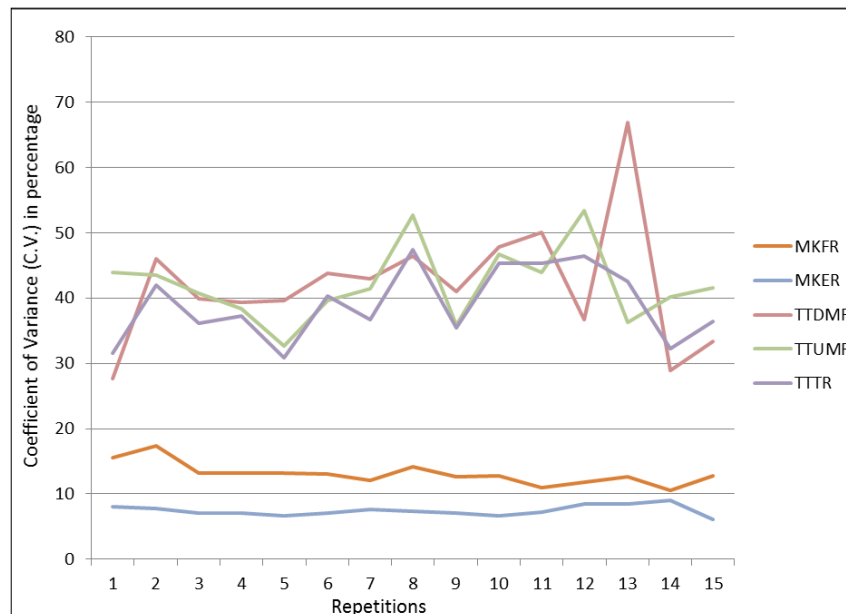


Fig 5: Line Diagram of Percentage Distribution of Coefficient of Variance of Selected Variables of HCE.

The above Fig. 5, Shows that distribution of coefficient of variance of selected angle variable of HCE namely Maximum Knee Extension Repetition Wise (MKER) are homogenous for 15 repetitions but heterogeneous for the remaining angle and temporal variables namely Maximum Knee Flexion

Repetition Wise (MKFR), Time Taken For Downward Movement Repetition Wise (TTDMR), Time Taken For Upward Movement Repetition Wise (TTUMR), and Total Time Taken Repetition Wise (TTTR).

Table 3: Analysis of Variance among the Repetitions of HCE.

Variables		Sum of Squares	df	Mean Square	F	Sig.
MKFRM	Between Groups	328.747	14	23.482	0.425(NS)	0.961
	Within Groups	3316.800	60	55.280		
	Total	3645.547	74			
MKERM	Between Groups	230.587	14	16.470	0.155(NS)	1.000
	Within Groups	6357.200	60	105.953		
	Total	6587.787	74			
TTDMRM	Between Groups	0.663	14	0.047	1.154(NS)	0.333
	Within Groups	2.461	60	0.041		
	Total	3.124	74			
TTUMRM	Between Groups	3.158	14	0.226	0.705(NS)	0.760
	Within Groups	19.184	60	0.320		
	Total	22.342	74			
TTTRM	Between Groups	3.679	14	0.263	0.594(NS)	0.859
	Within Groups	26.539	60	0.442		
	Total	30.218	74			
MKFRF	Between Groups	167.067	14	11.933	0.176(NS)	1.000
	Within Groups	4061.600	60	67.693		
	Total	4228.667	74			
MKERF	Between Groups	559.947	14	39.996	0.479(NS)	0.936
	Within Groups	5006.400	60	83.440		
	Total	5566.347	74			
TTDMRF	Between Groups	1.604	14	0.115	0.328(NS)	0.988
	Within Groups	20.991	60	0.350		
	Total	22.595	74			
TTUMRF	Between Groups	2.181	14	0.156	0.263(NS)	0.996
	Within Groups	35.566	60	0.593		
	Total	37.746	74			
TTTRF	Between Groups	3.674	14	0.262	0.165(NS)	1.000
	Within Groups	95.549	60	1.592		
	Total	99.223	74			

Note: N = 10, MKFRM/F = Maximum Knee Flexion Repetition Wise Male/Female, MKERM/F = Maximum Knee Extension Repetition Wise Male/Female, TTDMRM/F = Time Taken For Downward Movement Repetition Wise Male/Female, TTUMRM/F = Time Taken For Upward Movement Repetition Wise Male/Female, TTTRM/F = Total Time Taken Repetition Wise Male/Female. MKFRM, MKERM, MKFRF and MKERF measurements in degree, TTDMRM, TTUMRM, TTTRM, TTDMRF, TTUMRF and TTTRF measurements in seconds, NS = Not significant at 0.05 level.

From the analysis of table 3, it was found that selected variables of HCE are insignificant at 0.05 level, while compared among the repetitions.

5. Conclusions

- The comparisons among the repetitions reveals insignificant difference (i.e. movement constancy) in regard to variables namely MKFR, MKER, TTUMR, TTDMR, and TTTR of HCE.
- The comparisons among the players of each repetition demonstrated heterogeneity in regard to angle and temporal variables namely maximum knee flexion repetition wise (MKFR), time taken for downward movement repetition wise (TTDMR), time taken for upward movement repetition wise (TTUMR) and total time taken repetition wise (TTTR) of HCE.
- The comparison among the players of each repetition demonstrated homogeneity in the angle variable namely maximum knee extension repetition wise (MKER) of HCE.

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