RESEARCH ARTICLE

EFFECTS OF DOSE-RESPONSE OF NORDIC HAMSTRING EXERCISE ON MUSCLE PERFORMANCE IN ATHLETES, A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: The Nordic Hamstring muscle training is effective for eccentric strengthening of the hamstring in a sports population. Due to its high volume, its compliance is low and researchers are working to find out its lowest effective dose. **Objectives:** To determine the effects of dose-response of Nordic hamstring exercise on hamstring muscle performance. **Methods:** A randomized controlled trial was conducted from August to November 2020 and comprised of athletes of both genders who were randomized into high (3 times/week, 4 weeks) and low volume (1 time/week, 4weeks) Nordic hamstring exercise groups. The Outcome measures were taken using the single leg hamstring bridge test for hamstring strength, 30-m speed test, agility T-test, anthropometric measurement at 5cm, 10cm, 15cm above the patella. The assessments were taken at baseline, 2nd and 4th weeks. The data were analysed using SPSS 23. **Results:** There were 30(88.2%) males and 4(11.8%) females with a mean age of 23.41±3.67years and a mean BMI of 18.6±3.16. A significant difference ($p<0.001$) was observed between both groups for all outcome variables post-exercise protocol at 2nd and 4th week. **Conclusion:** The Nordic hamstring exercise was effective in improving hamstring muscle performance. The higher dose of Nordic Hamstring Exercise was more effective than the lower dose in improvement in muscle size, strength, speed and agility of the participants after 4 weeks of training.

Keywords: Agility, athletes, hamstring injuries, muscle strength, nordic hamstring exercises, speed

INTRODUCTION

Hamstring muscle injuries are most commonly occurring in sports-related injuries[1]. These career-threatening injuries have a high rate of recurrence ranging from 14-63%[2]. The engaging every fifth player per season leads to a high cost of treatment. The modifiable risk factors are inadequate eccentric hamstring strength, poor balance, high speed running with a quick change in directions, inadequate hamstrings/quadriceps ratio, inadequate warm-up, poor flexibility prpredisposinghe hamstring injury[3]. About 60-80% of hamstring injuries happen in the late swing phase, the position the muscle works eccentrically[4]. So the treatment options that focus on the eccentric strengthening of the muscle are more promising in the prevention of hamstring strain injuries[5].

Hamstring Muscle Strength and architecture are both improved with training[5]. The Nordic hamstring exercise(NHE) was first introduced by Mjølsnes et al with 700 repetitions across 10-weeks eccentric Nordic hamstring exercise (NHE) protocol with better results in hamstring strength as compared to concentric group (hamstring curl)[6].But this high volume exercise is probably the reason of low compliance and high Delayed Onset Muscle Soreness[7]. According to a meta-analysis, Nordic hamstring exercises can reduce the risk of hamstring strain injuries by 51%[1]. several studies suggest that Nordic hamstring exercise(NHE) can reduce hamstring injuries recurrence by 85% in previously injured athletes[8]. Performing 6 sets of 5 repetitions Nordic hamstring exercise (NHE) per week the strength of the hamstring was incredibly increased[9] Preventive effects of (Nordic hamstring exercise) NHE are seen with the threshold of 4-6 weeks dose[6]. The Volume of training is the number of repetitions multiplied by the number of sets. Studies showed that both the high and low volume protocols are effective in increasing strength and reducing injuries[1].3 sets of 3 repetitions, 3 times per week is considered the lowest nordic hamstring protocol[6]. Researches are being done to find out the minimum dose of exercise protocol that produce the desirable effects of hamstring strength[1, 4, 6, 10].

Hamstring strengthening results in improvement of athlete's performance by producing the desired effects. The important performance indicators are speed and agility in almost all the sports. Speed is the ability of the athlete to move in the fastest possible way[11]. The NHE has proven effects on enhancing the speed of many sports players[12]. Agility is the ability to cross the hurdles and change directions in the fastest possible way[13]. The effects

of NHE on agility are yet to be found according to previous literature[6].

Even in the face of promising NHE preventive effect shown by previous studies, adoption and compliance of the NHE programs are still low[6]. Evidence suggests that lowest dose of NHE required to enhance athletes' performance is yet to be found. So the current study was planned to determine the lowest dose-response of Nordic hamstring exercise on strength, muscle size, speed as well as agility.

METHODOLOGY

This single-blinded randomized control trial was conducted at JKD (Jeet Ker Dikhao) cricket academy and Sports center Peshawar, Pakistan from July 2020 to January 2021. The study protocol is registered at national library of medicine (NCT04668105) and ethically approved from Riphah ethical committee REC/00789. The sample size was calculated through Open Epi tool.

The sample was collected using the non-probability convenience sampling technique. The athletes of both gender, aged between 18 and 30 years, BMI between optimum range 18.5-24.5 kg/m^2, belonging to cricket, football, sprinters and badminton participating at least 6 months in relevant sports and COVID-19 negative and free from symptoms. The athletes having history of knee injury < 6 months, had knee or hip, spine surgery, the ruptured knee or ankle ligaments torn and those that withdraw from training were excluded from the study. A total of n=50 athletes were evaluated for eligibility criteria, out of which n=16 were excluded for not meeting the criteria. So the Sample size of n=34 athletes were randomly allocated to Group A (n=17) received the High volume Nordic hamstring exercise (HV-NHE) training and group B (n=17) received low volume Nordic Hamstring Exercise (LV-NHE). (Figure 1)

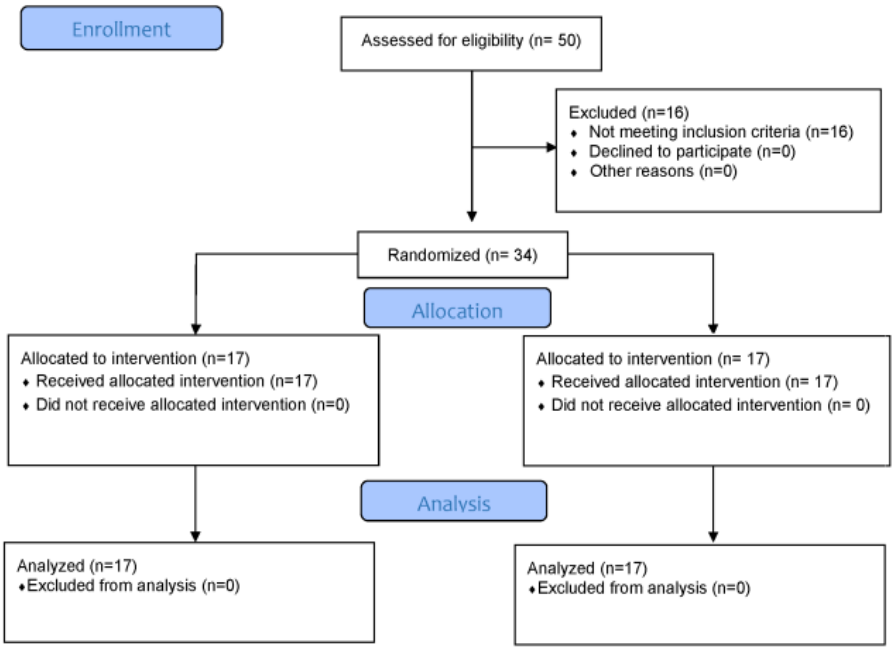

Figure 1: CONSORT diagram

After taking the informed written consent, the baseline data for strength was obtained using the Single Leg Hamstring Bridge which is a valid and reliable clinical test of hamstrings muscle strength for athletes[15,16]. The agility was measured through a T-test which is a reliable and valid tool to measure the agility of athletes[17] with cut-off values of 12.5 and 10.5. The speed was assessed through the 30-m speed test with validity and reliability of the 30-m speed test is 0.94 to 0.98 respectively[18]. The size of the hamstring was measured through an anthropometric measuring tape around the thigh circumference. The tape is placed 5, 10, and 15 cm proximal to the upper pole of the patella.

The intervention given to the group A, High volume Nordic hamstring exercise (HV-NHE) group was Nordic hamstring exercise for the eccentric hamstring strength. The athlete kneeled on the

ground to stabilize his ankles and hold them in place with the help of a partner. The athlete lean forward from his knees, not his hips and the movement must be controlled and kept slow while the participant moved forward / low as much as possible without the help of hands or arms. He was allowed to put his hands in front only when he cannot rely on his feet and pushing himself back to return to their original position and repeat the procedure[5]. Athletes performed the high-volume Nordic hamstring exercise with protocol of 3 repetition× 3sets× 3 times for 4 weeks. the total dose was 27 repetitions per week with 108 repetitions in 4 weeks[10]. It is the otherwise lowest according to previous literature[6]. The intervention given to group B, low volume Nordic hamstring exercise (LV-NHE) group was the same Nordic hamstring exercise for the eccentric hamstring strength. But the athletes received low volume Nordic hamstring exercise with the protocol of 3 repetition × 3 sets × 1 time for 4 weeks even lower than the previous one. It was 9 repetitions per week with 36 repetitions in total.

Both the groups were assessed for outcome at baseline, after 2nd weeks and 4th week of intervention. The assumptions of parametric tests were not met for hamstring strength speed and agility and the muscle size measurements. So the Mann Whitney u-test was used for between the group analysis and Friedman test with Wilcoxon sign rank test was used for intra group changes of hamstring strength, speed and agility. The data was analysed using IBM SPSS version 21.0.

RESULTS

The mean age of the HV-NHE group was 23.71±3.601 years and 23.12±3.822 years in LV-NHE group was 23.12±3.822 years. There were n=30(88.2%) males and n=4(11.8%) females in the study. The mean BMI in the HV-NHE groups was 19.87.05±3.69 and 17.32±3.93 in the LV-NHE group.

The intragroup analysis showed significant improvement (p<0.001) in both group observed from baseline to at the end of 4th week, as well as at all levels from baseline to end of 2nd week, 2nd week to end of 4th week in strength, agility, speed and hamstring muscle size of the athletes. (table 1)

The intergroup analysis showed that all variable were comparable at the baseline. After that significant improvement (p<0.001) observed in group A (HV-NHE) as compare to group B (LV-NHE) in all variables at 2nd and 4th week, except at 2nd week speed improvement was not significantly different (p=0.218), but after 4th week HV-NHE showed significant improvement (p=0.02) as compare to LV-NHE. (table 2)

Table 1: Intra-group changes in HV-NHE and LV-NHE groups

Variable	Assessments	Group A (HV_NHE) Median(IQR)	Mean Rank	Z/X^2(df)	p-value	Group B (LV-NHE) Median(IQR)	Mean Rank	Z/X^2(df)	p- value
Agility	Baseline	10.5(2.7)	3	3.62	0.00***	14(3)	3	3.62	0.00***
	After 2nd week	7(0)	2	3.94	0.00***	9(0)	2	3.94	0.00***
	After 4th week	5(0)	1	34 (2)	0.00***	9(1)	1	34 (2)	0.00***
SLHB	Baseline	13(4)	1.15	3.06	0.00***	14(3)	1.15	3.23	0.00***
	After 2nd week	17(1)	1.94	3.58	0.00***	16(1)	2.09	2.89	0.00***
	After 4th week	19(1)	2.91	27.3 (2)	0.00***	17(1)	2.76	25.9 (2)	0.00***
30m speed	Baseline	4.5(0.35)	3	3.62	0.00***	4.3(0.2)	3	3.63	0.00***
	After 2nd week	2(1.4)	1.71	2.73	0.00***	2.5(0.5)	1.76	2.70	0.00***
	After 4th week	2(0.35)	1.29	31.1 (2)	0.00***	2.5(1)	1.24	29.6(2)	0.00***
MSM 5cm	Baseline	39(5)	1.09	3.43	0.00***	37(2)	1.03	3.60	0.00***
	After 2nd week	42(4)	1.94	3.52	0.00***	39(1)	2.06	3.42	0.00***
	After 4th week	46(.2)	2.94	31.5 (2)	0.00***	42(3)	2.91	31.1 (2)	0.00***
MSM 10cm	Baseline	45(4)	1.21	2.76	0.00***	41(4)	1.15	3.14	0.00***
	After 2nd week	45(4)	1.91	3.31	0.00***	42(2)	1.85	3.64	0.00***
	After 4th week	45(1)	2.88	27.8 (2)	0.00***	45(1)	3	32.1(2)	0.00***
MSM 15cm	Baseline	44(6)	1.18	3.13	0.00***	44(4)	1.35	2.84	0.00***
	After 2nd week	46(2)	1.82	3.64	0.00***	45(1)	2.6	2.35	0.00***
	After 4th week	48(1)	3	29.9 (2)	0.00***	46(1)	2.59	18.9	0.00***

[a]Baseline to after 2nd week, [b]2nd week to after 4th week, [c]baseline to after 4th week
*Level of significance: p<0.001***, p<0.01**, p<0.05**

Table 2: Inter-group comparison at baseline, 2nd week and 4th week

Variable	Assessments	Group A (HV-NHE)		Group B (LV-NHE)		p- value
		Median(IQR)	Mean Rank	Median(IQR)	Mean Rank	
Agility	Baseline	10.5(2.7)	19.47	14(3)	15.53	0.248
	After 2nd week	7(0)	9.50	9(0)	25.50	0.00***
	After 4th week	5(0)	9.50	9(1)	25.5	0.00***
SLHB	Baseline	13(4)	15.5	14(3)	19.50	0.23
	After 2nd week	17(1)	21.9	16(1)	13.09	0.005**
	After 4th week	19(1)	25.06	17(1)	9.94	0.00***
30m speed	Baseline	4.5(0.35)	19.47	4.3(0.2)	15.53	0.241
	After 2nd week	2(1.4)	15.44	2.5(0.5)	19.56	0.218
	After 4th week	2(0.35)	13.79	2.5(1)	21.21	0.02*
MSM 5cm	Baseline	39(5)	20.56	37(2)	14.44	.070
	After 2nd week	42(4)	23.38	39(1)	11.62	0.00***
	After 4th week	46(.2)	25.85	42(3)	9.15	0.00***
MSM 10cm	Baseline	45(4)	19.18	41(4)	15.82	.322
	After 2nd week	45(4)	22.21	42(2)	12.79	0.005**
	After 4th week	45(1)	24.59	45(1)	10.41	0.00***
MSM 15cm	Baseline	44(6)	18.0	44(4)	17.0	.768
	After 2nd week	46(2)	24.88	45(1)	10.12	0.00***
	After 4th week	48(1)	26.0	46(1)	9.0	0.00***

*Level of significance: p<0.001***, p<0.01**, p<0.05**

DISCUSSION

The results indicated that higher volume of Nordic hamstring exercise (HV-NHE) was more effective for improvement in strength, speed, agility compared to low volume of Nordic hamstring exercise (LV-NHE) at both 2nd and 4th week. In addition, both groups had significant improvement in performance across all parameters.

The Nordic hamstring exercise has previously proven its efficacy on improve of the various parameters of hamstring muscle performance[1, 4, 6]. Systematic review suggests the significant effects with the dose of the NHE ranges between 21- 73 repetitions.[6] The risk of the hamstring injuries increases due to lack of muscle strength. The recommended dose of volume to increase muscle strength is ≤6 with 80%1RM [19]. So the fewer repetitions are performed to produce the strength gain effects. Previously 27 per week and 108 for 4 weeks are considered to be lowest effective dose that have significant improvement for hamstring strength.[10]

Systematic review is being done to find the lowest volume to gain hamstring strength[6]. Presland et al (high volume 440 reps, low volume 128 reps) found that both the high and low volume results in the significant effects on hamstring muscle strength.[20]This evidence somehow support the current study in which both the high and low volume produced the significant effects. But the high volume produces better results. The reason to this is that the 108 repetitions are proven in evidence to increase the biceps femorus architectural length[20]. The dosage less than this probably will not be able to produce the same effects. High volume (108 reps) used in this study was the one that was used as lowest volume in literature [6] and suggestions were to find still lowest volume. So probably the repetitions are to be improved a little in future studies to get equal gain in strength. The current study showed that the 36 repetitions volume produce positive effects in the hamstring strength but these results are not comparable with the higher volume Nordic hamstring curl.

In addition, improvement in hamstring size, which is specific to hamstring muscle performance taken at three levels, was found to increase in both groups over 2nd and 4th weeks. Contemporary evidence support this finding[20,21]. Whereas Nordic hamstring exercise increases both the volume and physiological cross sectional area of hamstring muscle. Hence it is used as an effective training method for muscle hypertrophy[21]. In the current study, both the groups show increase in the size of the muscle at 3 different levels. But high volume produces the better results particularly from 2nd to 4th week the reason to this is the hypertrophy mechanics explained in the literature [21].

The Nordic hamstring exercise increases the sprint performance by improving the hamstring strength and size. [12] The data of the current study is in line with the data where the Nordic hamstring exercise increases the speed performance in 5m and 10m sprint and in jump height of the athletes without

compromising their other performance measures[12]. Further findings indicated improvement in agility in both the high and low volume groups. The agility was marked as limitation in the previous systematic review on the dosage of Nordic hamstring exercise[6] which was fulfilled in the current study.

The current study has some limitations, including lack of follow up to look for the injuries in the future and to see the sustainability effects of the training. The compliance and the DOMS effects were not observed.

CONCLUSION

Higher and lower dose Nordic hamstring exercises (NHE) were effective in improving hamstring strength, size, speed and agility. However, the high dose of NHE was more effective than low dose after 4 weeks of training in improvement in strength, size, speed and agility of hamstring than speed. Further studies should be conducted on individual games separately as each game has its own techniques and performance parameters.

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