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Different Interset Rest Intervals During the Nordic Hamstrings Exercise in Young Male Athletes

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Context: The Nordic hamstring exercise (NHE) is known to reduce hamstrings injury risk in athletes. To optimize the NHE, it is important to understand how acute resistance-training variables influence its performance.

Objective: To examine the effects of different interset rest intervals (ISRIs) on force indices during performance of the NHE.

Design: Crossover study.

Setting: Laboratory.

Patients or Other Participants: Ten well-trained, young, male, team-sport athletes (age = 20.7 ± 2.3 years, height = 179.4 ± 5.5 cm, mass = 83.9 ± 12.4 kg).

Intervention(s): Participants performed 2 sets of 6 repetitions of the NHE with either a 1- or 3-minute ISRI. All sets were performed using the NordBord.

Main Outcomes Measure(s): Peak force (newtons), average force (newtons), percentage maintenance, and percentage decline were recorded for both the dominant and nondominant limbs, and interlimb force asymmetries (percentages) were calculated.

Results: No interactions or main effects ($P > .05$) were present between conditions or sets for any variables. However, individual repetitions showed reductions ($P < .05$; effect size range = 0.58–1.28) in peak force from repetition 4 onward.

Conclusions: Our findings suggest that a 1-minute ISRI was sufficient to maintain force-production qualities and interlimb asymmetries between sets during the NHE in well-trained athletes. Nonetheless, practitioners should be aware of the potentially large decrements in peak force production that may occur within the set.

Key Words: youth sports, eccentric, resistance training, injury prevention

Key Points

- Minimal reductions in eccentric hamstrings force indices between sets occurred when well-trained individuals performed the Nordic hamstring exercise (NHE).
- A 1-minute rest interval between NHE sets was adequate to maintain performance, although 3 minutes may provide modest benefits.
- The structure of the NHE set may be enhanced by performing fewer repetitions to ensure that peak force is maintained throughout the set.

To maximize an athlete's adaptation to imposed stimuli during resistance training (RT), an athletic trainer can manipulate several program-related factors, such as the interset rest interval (ISRI), muscle action type, loading and volume, and exercise order and frequency. Of these, the ISRI is critical in underpinning both the acute and chronic responses to RT because its duration influences the development of physical qualities, such as muscle strength and power.[1] This is because an extended ISRI facilitates the restoration of adenosine triphosphate and phosphocreatine by approximately 85% within 3 minutes of exercise cessation,[2] making it reasonable to assume that the longer the ISRI, the greater the acute benefit that is derived from RT performance. Previous research[3] supported this assertion, as greater improvements in muscle strength were reported with a 3-minute (LONG) than a 1-minute (SHORT) ISRI. Accordingly, when targeting increases in muscle strength, practitioners are encouraged to use a longer ISRI. However, whether this approach is applicable to all muscle action types is unknown.

Despite recommendations for prescribing the ISRI during RT, current guidelines are based on exercises that emphasize a predominantly concentric muscle action. Considering the distinctive nature of physiological responses to eccentric muscle actions, the prescription of eccentric RT exercises requires a more targeted approach.[4] For example, the energy cost of eccentric muscle actions is lower than that of concentric muscle actions.[5] Furthermore, during isokinetic exercises of the knee extensors, eccentric muscle actions were more resistant to fatigue than were concentric actions.[6] Because less fatigue is experienced during eccentric muscle actions, it is plausible that, during eccentric RT, longer ISRIs may not be warranted in the same manner as for concentric-dominant exercises. This may be of particular importance to practitioners when implementing an injury-prevention program, considering that time constraints are a perceived barrier.[7] Therefore, information about how the ISRI influences performance during eccentric RT can provide clinicians with further knowledge of how to optimize the training prescription. This is especially necessary because practitioners place a high degree of importance on developing eccentric strength in injury-prevention programs.[7]

An eccentric RT exercise that is known to reduce the risk of hamstrings injuries in athletes is the Nordic hamstrings exercise (NHE), which has been noted to reduce hamstrings injuries by up to 51% in athletes.[8] This was attributed to the benefits it conveys in developing eccentric hamstrings strength and muscle architectural properties, such as increased fascicle length.[9] To date, researchers have shown that the NHE improves both eccentric hamstrings torque and endurance[10] and reduces interlimb asymmetries.[11] This is particularly relevant given that factors such as low eccentric hamstrings strength,[12] high eccentric hamstrings force asymmetries,[13] and hamstrings fatigue[14] have been cited as increasing the risk of hamstrings injuries. However, although several factors related to the effective training prescription of the NHE are known, limited information exists concerning how the ISRI may influence its performance. Consequently, knowledge of how acute training prescription variables such as the ISRI may optimize performance of the NHE could provide clinicians with further guidance on its implementation in an injury-prevention program. Therefore, the purpose of our study was to examine the effects of a SHORT versus LONG ISRI on such measures during the NHE. Based on the lower levels of fatigue associated with eccentric muscle actions, we hypothesized that the length of the ISRI used for the NHE would not result in performance differences between sets.

METHODS

Design

We used a randomized, repeated-measures crossover design to assess the effect of different ISRIs on selected indices including force, asymmetries, and fatigue during the NHE. The randomization was conducted according to a computer-generated sequence (www.randomizer.org). Participants were required to execute 2 sets of 6 repetitions of the NHE with either a SHORT (1-minute) or LONG (3-minutes) ISRI. We divided participants into 2 groups, and they performed 1 condition in their first session before changing to the other condition in the following session (76–96 hours apart). The NHE dosage was chosen for consistency with a previous investigation[15] that demonstrated positive changes in eccentric hamstrings strength in young team-sport athletes when this prescription was included. In addition, this dosage was similar to the protocol in the participants' current training programs. Although all participants had previous exposure to the NHE, a familiarization session was required to fully prepare them for the laboratory procedures and performance of the exercise on the NordBord apparatus (Vald Performance) and to ensure they met the inclusion criteria. Before SHORT and LONG sessions, participants completed the same standardized 10-minute warmup, including low-intensity jogging, change-of-direction drills, lower limb dynamic stretching, and jumping-based tasks. All testing sessions occurred at the same time of day (approximately 8:00 AM).

Participants

An a priori power analysis was conducted (version 3.1.9.4; G*Power, University of Düsseldorf[16]) to determine the minimum sample size needed to find a difference with a desired power level of 0.80, α error of .05, and effect size (ES) of 0.53 based on earlier research[15] on the effects of NHE training in young male soccer athletes. Subsequently, the sample consisted of 10 young male team-sport athletes (age = 20.7 $\pm$ 2.3 years, height = 179.4 $\pm$ 5.5 cm, mass = 83.9 $\pm$ 12.4 kg). Participants were physically active and undertaking 2 to 3 sessions of supervised RT and 3 to 5 sport-specific practices per week. Given that previous hamstrings injuries can influence indices such as force and asymmetries, we required participants to meet the following inclusion criteria: (1) peak force eccentric hamstrings score of $\geq$337 N during the NHE,[12] (2) peak force asymmetry of <15% during the NHE,[13] (3) regular (ie, once per week) exposure to the NHE in current training, and (4) no lower limb injury in the 6 months before the study as documented by the team's medical department. Participants were instructed to avoid vigorous exercise and caffeine and alcohol consumption for a minimum of 24 hours before each testing session. The use of nutritional aids was prohibited throughout the testing process. All players provided written informed consent, and the Hartpury University Research Committee approved the study.

Procedures

Anthropometrics. Before testing started, we recorded age, stature, and body mass. Participants' standing height was measured using a stadiometer (model 213; Seca) to the nearest 0.1 cm, and mass was measured using a calibrated electronic scale (model 813; Seca) to the nearest 0.1 kg.

Eccentric Hamstrings Strength. The NHE was performed using the NordBord, which has been shown to be a reliable device (coefficient of variation range = 6.1%–7.4%) for assessing eccentric hamstrings strength in young male athletes.[17] All testing occurred in the university's performance gymnasium. For the assessment of eccentric hamstrings strength, participants knelt on the padded part of the NordBord and their ankles were secured using padded hooks that were attached to load cells. Each person's position was altered so that his ankles were perpendicular to the lower leg, and the hooks were positioned superior to the lateral malleolus. Participants were instructed to gradually lower the upper body while trying to resist the movement by contracting the hamstrings and holding the trunk and hips in a neutral position throughout. Their arms were flexed at the elbow joints such that their palms faced forward at the level of the shoulder joints to help buffer the fall as they approached the ground. For the ascent, participants were assisted back to the starting position. As soon as they reached the starting position, they were required to immediately begin the next repetition. *Peak force* (newtons), determined as the highest force output from a single repetition, and *average force* (newtons), calculated as the mean of the peak force outputs from all 6 repetitions, were recorded for each condition and set using LabChart (version 7.3; ADInstruments). All data were analyzed using a predesigned Excel spreadsheet (Microsoft Corp), with the scores from each limb calculated.

Calculating Asymmetry and Fatigue. Interlimb asymmetries for each set were quantified and calculated in accordance with current recommendations.[18] Specifically, the mean score from the peak force values of each limb across the set was recorded, and the magnitude of the interlimb asymmetries was calculated using the percentage difference method: 100/maximum (right and left)/minimum (right and left) $\times -1 + 100$. The ability to maintain force during all repetitions in each set was assessed using the following equation: percentage maintenance $= 100 - [(\text{mean set} - \text{repetition}_1)/\text{repetition}_1] \times 100$.[19] In addition, the effect of the ISRI length in each condition was determined by a percentage decline from the first to the 12th repetition using the following equation: percentage decline $= [(\text{repetition}_{12} - \text{repetition}_1)/\text{repetition}_1] \times 100$.[19]

Statistical Analyses

All data from each NHE repetition were recorded and entered into Excel (version 16.0.4) to compute means and SDs. The subsequent statistical analysis was performed using SPSS (version 26; IBM Corp) with statistical significance set at $P < .05$. Normality was assessed via the Shapiro-Wilk test. A 2-way repeated-measures analysis of variance was conducted to assess differences in peak force between conditions (SHORT versus LONG) for individual repetitions (repetitions 1 to 6) in sets 1 and 2. Subsequently, we used simple planned contrasts to assess changes in peak force between repetition 1 and subsequent repetitions. A 2-way repeated-measures analysis of variance was also calculated to assess differences in conditions between sets (set 1 versus set 2) for all force index measures (peak force, average force, percentage maintenance, and interlimb asymmetries). When an F ratio was significantly different, post hoc comparisons were performed using a Bonferroni correction. The independent-samples t test was used to assess differences between the dominant and nondominant limbs, as well as the percentage decline between conditions. The ESs were determined using the Cohen d and defined using the following thresholds: <0.20, *trivial*; 0.20 to 0.59, *small*; 0.60 to 1.19, *moderate*; 1.20 to 1.99, *large*; 2.0 to 3.99, *very large*; and >4.0, *extremely large*.[20]

RESULTS

Force Production

All data were normally distributed ($P > .05$). The differences between repetitions in sets 1 and 2 for peak force are shown in Figure 1. In set 1, the dominant limb displayed no condition-by-repetition interaction ($F_{5,45} = 0.570$, $P = .72$) or main condition effect ($F_{1,9} = 0.574$, $P = .47$) for peak force, although a main repetition effect was observed ($F_{5,45} = 7.636$, $P < .001$). Planned contrasts revealed that peak force was lower in repetitions 4 ($t_{45} = -2.852$, $P = .01$, ES = 0.58, –4.86% decline), 5 ($t_{45} = -4.026$, $P < .001$, ES = 0.94, –7.57% decline), and 6 ($t_{45} = -4.385$, $P < .001$, ES = 1.13, –8.25% decline) than in repetition 1. In set 2, the dominant limb demonstrated no condition-by-repetition interaction ($F_{5,45} = 0.128$, $P = .99$) or main condition effect ($F_{1,9} = 0.879$, $P = .37$) for peak force, but a main repetition effect was present ($F_{5,45} = 4.118$, $P = .004$). Planned contrasts indicated that peak force was lower in repetitions 5 ($t_{45} = -2.780$, $P = .008$, ES = 0.82, –4.53% decline) and 6 ($t_{45} = -4.106$, $P < .001$, ES = 0.85, –6.70% decline) than in repetition 1. Set 1 for the nondominant limb showed no condition-by-repetition interaction ($F_{5,45} = 0.704$, $P = .62$) or main condition effect ($F_{1,9} = 1.080$, $P = .33$) for peak force, but a main repetition effect was observed ($F_{5,45} = 8.175$, $P < .001$). Planned contrasts revealed that peak force was lower in repetitions 4 ($t_{45} = -3.334$, $P = .002$, ES = 0.77, –7.94% decline), 5 ($t_{45} = -4.820$, $P < .001$, ES = 1.26, –11.49% decline), and 6 ($t_{45} = -5.290$, $P < .001$, ES = 1.28, –12.61% decline) than in repetition 1. No condition-by-repetition interaction ($F_{5,45} = 0.399$, $P = .74$) or main effects for condition ($F_{1,9} = 1.678$, $P = .23$) or repetitions ($F_{5,45} = 1.517$, $P = .20$) were found for peak force in the

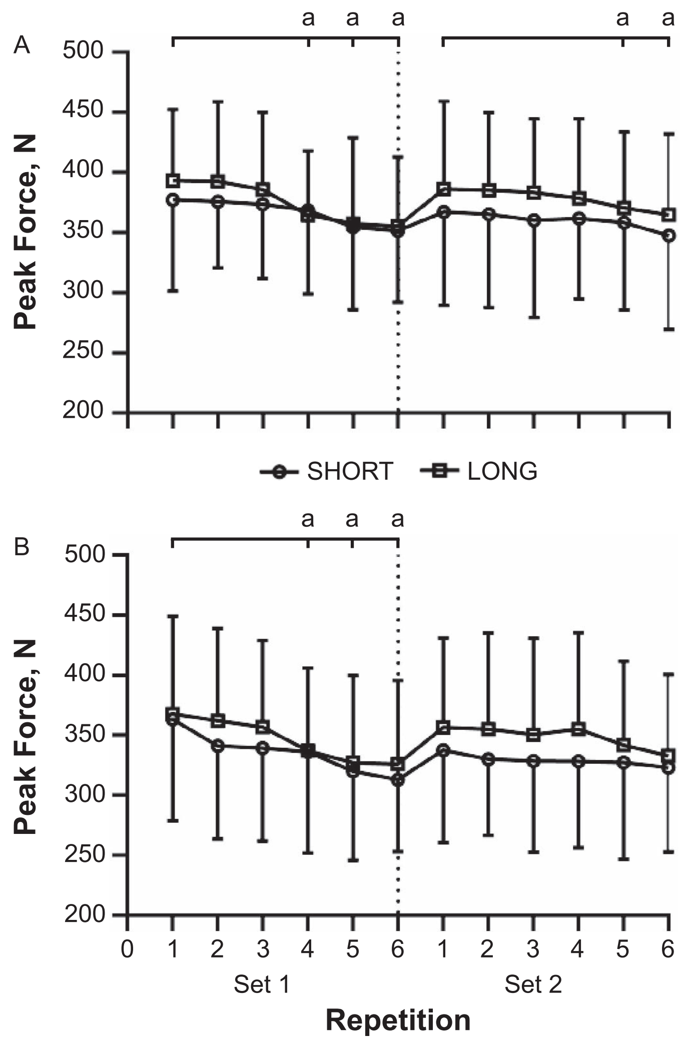

Figure 1. All individual repetitions for eccentric hamstrings peak force during the SHORT (1-min) and LONG (3-min) interset rest interval conditions (Mean ± SD). [a] Indicates a difference ($P < .05$).

Table. Changes in Eccentric Hamstrings Force Index Measures Between Sets During the SHORT and LONG Interset Rest Interval Conditions

Variable	Condition[a]	Set, Mean ± SD		Effect Size (90% CI)	Condition, Value		Set, Value		Condition × Set, Value	
					$F_{1,9}$	P	$F_{1,9}$	P	$F_{1,9}$	P
Peak force, N		1	2							
	Dominant limb				1.079	.33	1.228	.30	0.571	.47
	SHORT	398.60 ± 58.64	388.60 ± 69.35	−0.16 (−0.89, 0.59)						
	LONG	405.70 ± 62.88	406.30 ± 59.89	0.01 (−0.73, 0.74)						
	Nondominant limb				1.641	.23	2.452	.15	0.623	.45
	SHORT	371.00 ± 81.42	354.60 ± 73.50	−0.21 (−0.94, 0.53)						
	LONG	380.80 ± 80.94	374.70 ± 73.37	−0.08 (−0.81, 0.66)						
Average force, N	Dominant limb				0.998	.33	0.103	.76	0.771	.40
	SHORT	366.63 ± 61.17	360.40 ± 70.90	−0.09 (−0.83, 0.65)						
	LONG	374.63 ± 58.63	377.93 ± 62.29	0.05 (−0.68, 0.79)						
	Nondominant limb				1.851	.21	0.402	.54	0.376	.56
	SHORT	335.55 ± 73.38	329.18 ± 71.04	−0.09 (−0.82, 0.65)						
	LONG	346.18 ± 70.28	347.48 ± 73.62	0.02 (−0.72, 0.75)						
Maintenance, %	Dominant limb				0.046	.84	0.148	.71	1.164	.40
	SHORT	98.14 ± 8.15	96.35 ± 8.26	−0.22 (−0.95, 0.53)						
	LONG	95.31 ± 3.18	98.53 ± 5.57	0.71 (−0.08, 1.44)						
	Nondominant limb				0.136	.72	3.492	.09	1.017	.34
	SHORT	93.04 ± 7.00	98.00 ± 7.53	0.68 (−0.10, 1.41)						
	LONG	94.81 ± 6.23	97.43 ± 3.56	0.52 (−0.25, 1.24)						

[a] The SHORT condition was 1 minute, and the LONG condition was 3 minutes.

nondominant limb for set 2. The Table provides the differences between sets in the dominant and nondominant limbs for peak force, average force, and percentage maintenance. No condition-by-set interactions or main effects existed for peak force in the dominant and nondominant limbs (Figure 2). In addition, no differences occurred between the dominant and nondominant limbs for the SHORT ($t_{18} = 0.458$, $P = .65$, ES = 0.21) and LONG ($t_{18} = 0.593$, $P = .56$, ES = 0.27) conditions. No condition-by-set interactions or main effects were noted for average force in the dominant and nondominant limbs (Figure 3). In addition, no differences were demonstrated between the dominant and nondominant limbs for the SHORT ($t_{18} = 0.016$, $P = .988$, ES = 0.007) and LONG ($t_{18} = 0.170$, $P = .867$, ES = 0.08) conditions.

Fatigue

No condition-by-set interactions or main effects were evident for the percentage maintenance values in the dominant and nondominant limbs (Figure 4). In addition, no differences were seen between the dominant and nondominant limbs in the SHORT ($t_{18} = 1.452$, $P = .16$, ES = 0.65) and LONG ($t_{18} = -0.138$, $P = .89$, ES = –0.06) conditions. For the percentage decline values (Figure 5), no differences were present between the dominant SHORT and dominant LONG ($t_{18} = -0.151$, $P = .88$, ES = 0.07), nondominant SHORT and nondominant LONG ($t_{18} = -0.367$, $P = .72$, ES = 0.16), dominant SHORT and nondominant SHORT ($t_{18} = 0.566$, $P = .58$, ES = 0.25), and dominant LONG and nondominant LONG ($t_{18} = 0.138$, $P = .89$, ES = 0.06) conditions.

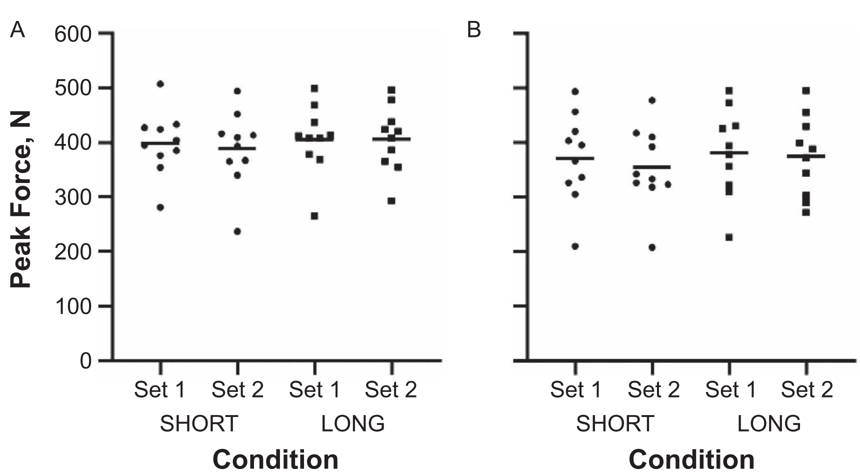

Figure 2. A, Mean and B, individual changes in eccentric hamstrings peak force during the SHORT (1-min) and LONG (3-min) interset rest interval conditions.

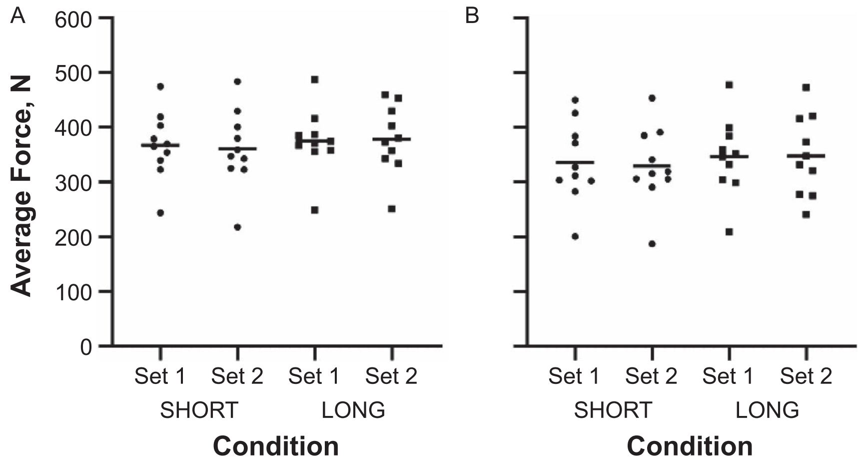

Figure 3. A, Mean and B, individual changes in eccentric hamstrings average force during the SHORT (1-min) and LONG (3-min) interset rest interval conditions.

Interlimb Asymmetries

Given the small variations between sets and small sample size, we calculated the percentage agreement between sets to determine the internal consistency of the direction of interlimb asymmetries. The percentage agreements for the tests were 90% and 70% for the SHORT and LONG groups, respectively. Interlimb asymmetries in the SHORT group were 8.99% ± 8.57% and 8.85% ± 5.08% for sets 1 and 2, respectively (Figure 6). In the LONG group, interlimb asymmetries were 8.06% ± 7.75% and 8.54% ± 8.16% for sets 1 and 2, respectively. No condition-by-set interactions ($F_{1,9} = 0.122$, $P = .74$) or main effects for condition ($F_{1,9} = 0.234$, $P = .64$) or repetitions ($F_{1,9} = 0.014$, $P = .91$) existed. The between-groups standardized mean differences for all measures are shown in Figure 7.

DISCUSSION

To our knowledge, we are the first to investigate the effects of the ISRI on NHE force indices. Although previous authors described the benefits of using a longer ISRI during RT for exercises that were largely concentric, we observed no differences between conditions or sets during the NHE, an eccentric exercise, for any force indices. However, although minimal, between-sets reductions in measures such as peak and average force production were lower during the LONG ISRI condition. Analysis of the individual repetitions showed that decrements in peak force occurred in the NHE set from repetition 4 onward. Overall, our results demonstrated that, whereas a 1-minute rest interval between sets is sufficient to maintain selected force indices during the NHE, peak force can begin to decrease midway through the set compared with the first repetition.

Our finding that the changes in force production values were not different between sets were in accordance with those of earlier researchers[21] who also noted no changes in hamstrings peak maximal eccentric torque during 6 sets of 5 repetitions each of the NHE. This result was somewhat expected because peak force is likely to occur at the beginning of the set, which was consistent with our results. Yet when the changes in peak and average force values in the dominant and nondominant limbs between sets were standardized between conditions (Figure 7), the LONG ISRI was more favorable, although the magnitude was small.

Comparatively, our finding that changes between sets were minimal during the NHE did not agree with the results

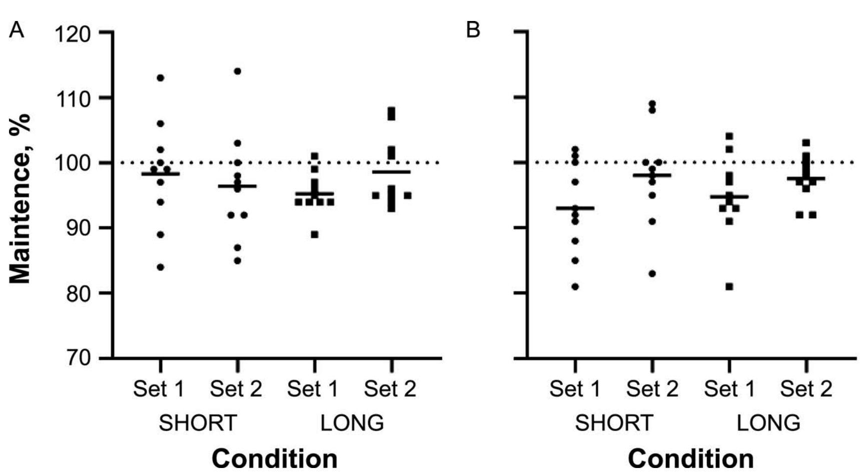

Figure 4. A, Mean and B, individual changes for percentage maintenance of eccentric hamstrings peak force during the SHORT (1-min) and LONG (3-min) interset rest interval conditions.

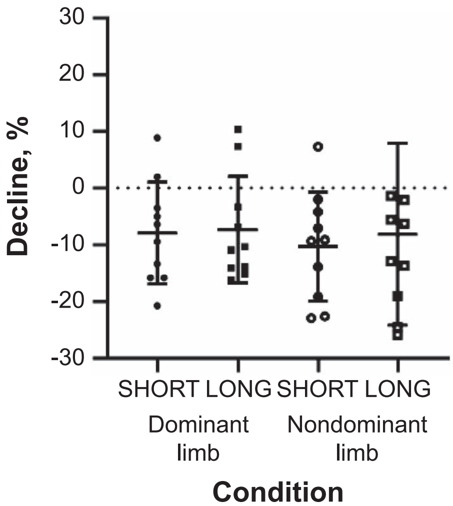

Figure 5. Percentage decline in eccentric hamstrings peak force during the SHORT (1-min) and LONG (3-min) interset rest interval conditions (Mean ± SD).

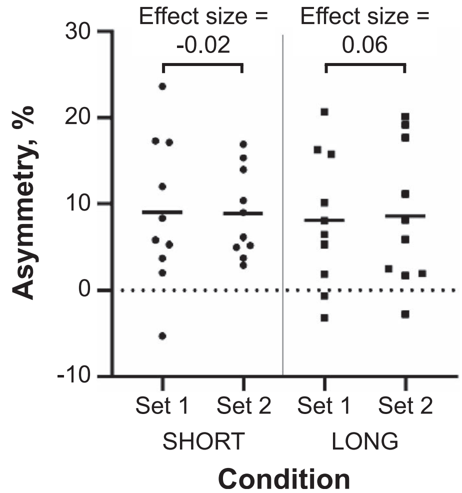

Figure 6. Mean (left) and individual (right) changes in eccentric hamstrings interlimb asymmetry between sets during the SHORT (1-min) and LONG (3-min) interset rest interval conditions.

of previous investigators[22] who assessed the ISRI during lower limb RT. For example, multiple sets of leg-extension exercise using a 10-repetition maximum load led to large reductions in performance by the second set, regardless of the duration of the ISRI (1-minute ES = 6.15, 3-minute ES = 1.54). The minimal influence of the ISRI during the NHE could be explained by the SHORT ISRI providing adequate time to recover between sets due to the eccentric muscle action that occurs during the exercise. Energy expenditure, carbohydrate use, and oxygen consumption were lower during eccentric than during concentric exercise.[5] Consequently, it is possible that, due to the eccentric nature of the NHE, a shorter ISRI between sets is sufficient to restore energy stores and thus maintain force production values in athletes familiar with the NHE.

Peak force decreased from repetition 4 onward compared with the first repetition in set 1 in the dominant and nondominant limbs and repetition 5 in set 2 for the dominant limb (Figure 1). Whereas direct comparisons with earlier work are difficult because of the differences between exercises, peak force during lower limb RT has been shown to decrease from repetition 1 to all subsequent repetitions when performing 6 repetitions of the loaded jump squat.[23] The reductions in peak force occurring later during the NHE set may reflect the lower metabolic costs that occur during eccentric muscle actions compared with concentric muscle actions, which consequently reduce mechanical force output.[24] Furthermore, the intermittent nature of the NHE may also help explain our findings. The time delay between the end of the descent phase and the return to the start position inadvertently provides a short rest interval between repetitions. Indeed, an inter-repetition rest was beneficial in reducing muscle metabolites and maintaining performance during lower limb RT.[25] Therefore, based on our findings, it may be permissible to use lower repetition ranges when prescribing the NHE or include a rest interval after each repetition to try to ensure that high levels of eccentric hamstrings force production are achieved throughout the whole set.

Percentage maintenance between sets did not differ, with participants achieving peak force values >93% across sets in both conditions. Interestingly, force maintenance values tended to be greater in the second set than in the first set. Our lower percentage maintenance values during the first set than the second set were in line with those of authors[26] who showed that the greatest declines in eccentric torque occurred at the beginning of the exercise before it reached a plateau. However, we believe the percentage decline values provide more accurate insight into the force reductions that occurred during the NHE than percentage maintenance values do. The percentage maintenance values in the set consider the mean of the peak force values from all 6 repetitions, whereas the percentage declines reflect the loss of force from the first to the 12th repetition. Consequently, the absolute percentage losses noted between repetitions 1 and 6 (>12%) along with the percentage decline values in all conditions (7%–10%) would suggest that the losses in force production during the NHE may in fact be high. For instance, losses in concentric peak force when performing 4 repetitions of the deadlift at 90% of the 1-repetition maximum and during 6 repetitions of the jump-squat exercise have been reported to be 2.3%[27] and approximately 3%, respectively.[23] Our results somewhat reflect the losses of up to 17% in average eccentric hamstrings torque described after 1 set of 5 repetitions of the NHE.[21] Subsequently, although eccentric muscle actions are known to be less fatiguing than concentric actions,[7] it may be that the specific nature of eccentric hamstrings actions means they are more susceptible to fatigue. Indeed, Paulus et al[28] recently showed that fatigue was more pronounced during eccentric exercise of the hamstrings muscles than the quadriceps muscles. Therefore, our results indicated that, when prescribing the NHE, practitioners should be cognizant of the potentially large decrements in force that can occur within the set and aim to minimize them.

The interlimb asymmetry values produced by our participants were similar to those observed in professional male team-sport athletes who had no history of hamstrings injuries in the previous season (8.77% ± 7.92%).[29] Thus, uninjured, well-trained individuals with experience performing the NHE should be expected to achieve eccentric hamstrings asymmetry values of <15% during the NHE. Indeed, individuals with higher values were at greater risk

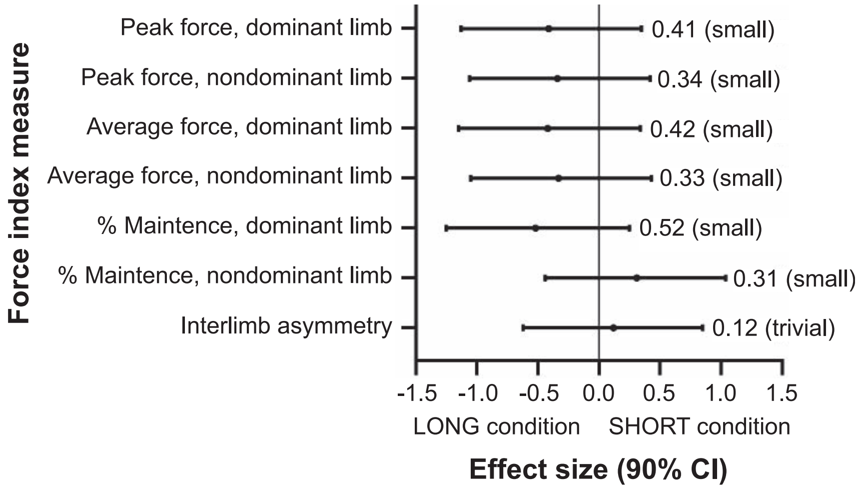

Figure 7. Between-conditions standardized mean differences with 90% CIs for force index measures.

of hamstrings strain injuries.[13] Furthermore, the high levels of variability in our asymmetry values are similar to those reported by investigators[29] who observed interlimb asymmetries during the NHE. Hence, per current recommendations, it is necessary to undertake an individual approach when interpreting interlimb asymmetry data.[30] As we found for other force index measures, interlimb asymmetries did not differ between sets or conditions. Our previous explanations for the minimal changes between sets for the other force index measures may also apply here, though our inclusion criteria that required participants to meet a minimum threshold of eccentric hamstrings strength and be injury free may also provide further rationale. For example, stronger athletes exhibited less asymmetry than did weaker athletes during lower limb strength tasks.[31] In addition, individuals with a history of hamstrings injuries displayed greater declines in knee-flexor torque production during an isokinetic endurance test in injured than uninjured legs.[14] Consequently, although further evaluation is required to determine how the ISRI length may influence eccentric hamstrings interlimb asymmetries between injured and uninjured athletes, our findings demonstrated that practitioners can use a SHORT ISRI during the NHE to maintain this quality.

Limitations

This study had certain limitations. We used SHORT and LONG ISRIs; therefore, considering the minimal differences observed between the SHORT and LONG groups, including a shorter ISRI might have provided more details regarding the minimum ISRI required. In addition, further analysis of changes in force indices across additional sets of the NHE as reported in the literature[21] might have offered insight into the fatigue aspects of exercise. However, using low-dose NHE training is a time-efficient strategy from a practitioner's perspective, and this approach was as effective in developing eccentric hamstrings strength and muscle architecture properties in young male team-sport athletes as higher volumes.[9] Also, the force indices we measured did not represent angle-specific changes in eccentric hamstrings force. This is important to acknowledge, as reductions in eccentric torque have occurred in the final 15° of range of motion after the NHE.[21] Consequently, future researchers should examine how the length of the ISRI influences angle-specific eccentric hamstrings forces, as well as the longitudinal effects of using a SHORT versus LONG ISRI, on eccentric hamstrings strength and muscle architecture properties.

CONCLUSIONS

To our knowledge, we are the first to examine the effects of different ISRIs during the NHE. Our results demonstrated that the use of a SHORT ISRI was adequate to maintain force indices and interlimb asymmetries between sets during the NHE. Thus, practitioners can use our findings when prescribing the NHE within an injury-prevention program for uninjured players who are accustomed to the exercise. However, clinicians should be aware of the potential for large reductions in eccentric hamstrings strength to occur during a set and, hence, an intraset ISRI may be useful. Overall, although our work provides practitioners with guidance on the effective prescription of the NHE, current guidelines for its prescription require additional study.

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