PELVIC LIST STRENGTH AS AN INDICATOR OF SPRINT PERFORMANCE

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This study aimed to develop a new test for evaluating pelvic list strength and to clarify whether the test would be an indicator of sprint performance. The new pelvic list strength test evaluated the vertical ground reaction force produced by maximal pelvic list using a force plate which was set underneath the supporting foot. For the experiment, 14 male sprinters performed 60-m sprint and the pelvic list strength test. The pelvic list strength test values were 6.05 ± 1.36 [N/kg] and 6.07 ± 1.02 [N/kg] for the right and left sides, respectively. Significant correlations were found between the right pelvic list strength and 60-m and 30 to 60-m sprint times (no significant correlation being found for the left side). The results demonstrate that the developed new test could be an indicator of the sprint performance especially during the later acceleration section.

KEYWORDS: pelvis, running, trunk, spatiotemporal variables, GRF.

INTRODUCTION: The pelvis moves three-dimensionally during sprinting (Nagahara et al. 2018). The pelvis tilts backward and then forward in the flight and support phases, respectively, during sprinting. In the transverse plane, the pelvis rotates inward (the ipsilateral part moved forward) during the support phase. In the coronal plane, the ipsilateral pelvis lists downward during the support phase and upward during the following flight phase. These pelvic motions during sprinting are generally maintained regardless of sprint sections (Nagahara et al. 2018). Regarding the pelvic list, ranges of motion could be greater than 30° during the initial steps and approximately 15° at the maximal speed during sprinting. Recently, it has been revealed that the pelvic list action during jumping could lead to an increase in jump distance through increasing vertical kinetic energy (Sado et al. 2023). Alongside this finding, pelvic list training has become common in the field of sprint training. Taken together, pelvic list strength would be important for dynamic exercise performance including sprinting. However, there is no measurement that can evaluate pelvic list strength. Suggesting a test to evaluate pelvic list strength is of great importance for practitioners when they intend to improve pelvic motion during sprinting through monitoring training progress. The purpose of this study was to develop a new test for evaluating pelvic list strength and to clarify whether the test would be an indicator of sprint performance.

METHODS: The new pelvic list strength test was developed as depicted in Figure 1. The test evaluated the vertical ground reaction force (GRF) produced by maximal pelvic list using a force plate (SS-FP40UD, Sports sensing, Fukuoka, Japan; 1000 Hz) which was set underneath the supporting foot. During the test, a participant was requested first to stand on the force plate using a single leg with pelvic listed position (contralateral side positioning low as much as possible) and to list the pelvis as fast as possible (the contralateral side moved upward) when the start cue was verbally provided. The test was performed with hands being on the waist and without swing of the free side leg. The maximal value of the vertical GRF during the test was extracted (Figure 2). Then, the body weight of the participant was subtracted from the maximal vertical force. Finally, the value was normalized to the body mass as a pelvic list strength value. For the experiment, participants were 14 male sprinters (age, 19.6 ± 1.0 years; stature, 1.74 ± 0.5 m; body mass, 69.3 ± 3.9 kg; personal best 100-m time, 11.23 ± 0.42 s). The aim and experimental procedures of this study were fully explained before the experiment, and written informed consent was obtained from the participants. The experiment was conducted with approval from the research ethics committee of the institute. The participants performed 60-m sprint during which GRF from the start to the 50-m mark was measured using a long force plate system (Tec Gihan, Uji, Japan; 1000 Hz) (Nagahara et al. 2019, 2020). The sprint was treated as a 100-m race with starting blocks, and the participant used his own crouched starting position. The times at the 30- and 60-m marks were recorded with a photocell system (TC Timing System, Brower Timing System, Draper, UT). Recording of the timer was initiated by the starting signal. The sprint was performed for two times and the faster trial based on the 60-m time was used for further analyses. Using the GRF data, averaged step length and frequency throughout sprinting over 50-m distance were calculated.

Figure 1: Example of the new pelvic list strength test.

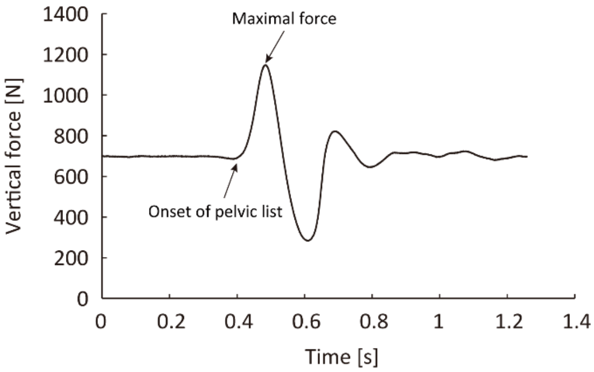

Figure 2: Example of detecting the maximal vertical force during the pelvic list strength test.

After the sprint trial, participants performed single leg vertical jumps and pelvic list strength test in a randomized order. The vertical jumps included squat (SJ) and counter movement jumps (CMJ), as well as rebound continuous jump (RJ). All jumps were performed without arm swing action. The jump heights and contact times were measured using a contact mat system (Multi Jump Tester; DKH Co., Tokyo, Japan). The contact mat system read the ON and OFF signals during foot contact on the ground and the flight of the body in milliseconds. All participants had performed jumping exercises for training and testing in their training program and were therefore familiar with all jumping tests. The SJ and CMJ were measured only for height. The RJ was measured for jump height, contact time, and jump index; i.e., the ratio of the jump height (m) divided by the contact time (s). The pelvic list strength test was performed as explained above. All participants had performed the pelvic list strength test at least five times before the experiment to familiarize themselves with it. The researchers confirmed that the participants were able to conduct the pelvic list strength test correctly. All the tests were performed twice and the best trial was selected for further analyses. The researchers checked whether the jumps and pelvic list strength test were performed correctly by visual assessment. If a participant performed the tests incorrectly, he was required to perform it again.
The means and standard deviations were calculated. Pearson's correlation test was used to analyze the relationship between two variables. The significance level was set at 5% for all tests.

RESULTS: The 30-, 60- and 30 to 60-m sprint times were 4.40 ± 0.17 s, 7.55 ± 0.28 s and 3.15 ± 0.12 s. The averaged step length and frequency for 50-m distance were 1.83 ± 0.06 m and 4.59 ± 0.22 Hz. Results for the pelvic list strength test and vertical jump tests are shown in Table 1.

Table 1: Means ± SD of pelvic list strength and single leg vertical jump test variables.

Variables [units]	Right	Left
Pelvic list strength [N/kg]	6.05 ± 1.36	6.07 ± 1.02
Squat jump height [cm]	27.2 ± 3.4	27.1 ± 4.6
Counter movement jump height [cm]	28.7 ± 3.1	28.4 ± 3.8
Rebound continuous jump height [cm]	23.6 ± 1.8	23.8 ± 2.8
Rebound continuous jump contact time [s]	0.236 ± 0.016	0.237 ± 0.018
Rebound continuous jump index [m/s]	1.00 ± 0.08	1.01 ± 0.11

Table 2 shows correlation coefficient between the vertical jump performances and the pelvic list strength test variables with leg side matched comparisons. There was no significant correlation between vertical jump test variables and pelvic list strength test variable for each side. Table 3 shows correlation coefficient between the sprint performances and the pelvic list strength test variables. Significant correlations were found between the right pelvic list strength and 60-m and 30 to 60-m sprint times.

Table 2: Correlation coefficients (P values) between the pelvic list strength and single leg vertical jump test variables for each side.

	Pelvic list strength test	
	Right	Left
Squat jump height	0.322 (0.262)	0.198 (0.498)
Counter movement jump height	0.347 (0.119)	0.276 (0.340)
Rebound continuous jump height	0.086 (0.771)	0.493 (0.073)
Rebound continuous jump contact time	−0.121 (0.680)	0.172 (0.556)
Rebound continuous jump index	0.196 (0.503)	0.395 (0.162)

Table 3: Correlation coefficients (P values) between the pelvic list strength and sprint performance variables.

	Pelvic list strength test	
	Right	Left
30-m time	−0.480 (0.083)	−0.056 (0.848)
60-m time	**−0.537 (0.048)**	−0.048 (0.871)
30- to 60-m time	**−0.581 (0.029)**	−0.032 (0.913)
Averaged step length for 50 m	0.105 (0.722)	−0.293 (0.309)
Averaged step frequency for 50 m	0.313 (0.276)	0.187 (0.522)

DISCUSSION: This study developed a test for evaluating pelvic list strength and examined its relationship with sprint performance using 14 sprinters. Although the values of pelvic list strength test (≈6 N/kg) were substantially smaller than the maximal vertical force during maximal speed sprinting (≈37 N/kg) (Nagahara et al. 2021), the force production duration was less than 0.15 s, indicating that the test could possibly measure ballistic force production capability of the pelvis. The non-significant relationships of the pelvic list strength test with vertical jump test variables for each leg indicate that the developed test in this study could evaluate specific strength related to pelvis that cannot be evaluated using commonly used vertical jump tests. The pelvic list strength for the right side was correlated with 60-m and 30- to 60-m times. These results demonstrate that the currently developed test could be an

indicator of the sprint performance especially during the later acceleration section. This in turn indicates the importance of pelvic list strength for better sprint performance, supporting a previous study that indicated the contribution of the pelvic list for jump distance (Sado et al. 2023). The pelvic list strength test was not correlated with both step length and frequency, whereas the magnitude of the correlation coefficient with step frequency was high (0.313). Because running speed can be calculated as a product of step length and frequency, pelvic list strength is possibly be related to higher step frequency rather than longer step length.
Although the developed new pelvic list strength test could evaluate specific strength related to sprint performance, a reliability of the test needs to be examined in the future. The participants in this study were national to regional level sprinters. Thus, it is possible that the results may differ for higher or lower level sprinters. Moreover, the maximum force was used as a variable of the test. The rate of force development, mean force etc. should be used as measures for the test.

CONCLUSION: This study aimed to develop a new test for evaluating pelvic list strength and to clarify whether the test would be an indicator of sprint performance. The developed new pelvic list strength test could evaluate specific strength that cannot be evaluated using commonly used vertical jump tests. Moreover, the developed test could be an indicator of the sprint performance especially during the later acceleration section. The currently developed test will be useful for monitoring pelvic list strength when trying to improve sprint performance.

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