

Effect of pelvic list training on dynamic exercise performances in basketball players

Kaori Maemura. *National Institute of Fitness and Sports in Kanoya. Kagoshima, Japan.*

Haruna Ikeshita. *National Institute of Fitness and Sports in Kanoya. Kagoshima, Japan.*

Ken Miura. *National Institute of Fitness and Sports in Kanoya. Kagoshima, Japan.*

 **Ryu Nagahara**  . *National Institute of Fitness and Sports in Kanoya. Kagoshima, Japan.*

ABSTRACT

Importance of pelvic list strength for physical fitness performances in basketball players has recently been suggested. The purpose of this study was to examine the effects of pelvic list training on physical fitness performance in female collegiate basketball players. Eleven athletes completed a 4-week pelvic list training program, performed four times per week, consisting of eight exercises. Physical performance measures including pelvic list strength, 20-m sprint, lane agility test, pro-agility test, countermovement jump, running jump and standing long jump were assessed before and after the training period. Following the training, pro-agility test time improved from 5.07 ± 0.15 s to 4.96 ± 0.12 s ($p = .097$). Moreover, significant increases were observed in right and left pelvic list strength, as well as right pelvic list strength with a 2 kg load ($p = .027$, $.033$ and $.003$, respectively). Furthermore, improvements in right pelvic list strength were associated with reductions in pro-agility test time ($r = -0.637$, $p = .065$). These findings suggest that pelvic list training can enhance pelvic list strength and may contribute to improvement in pro-agility test performance in female collegiate basketball players. The results may be useful for developing effective strength training programs for female basketball players.

Keywords: Performance analysis, Training, Pelvis, Trunk, Jump, Sprint running, Change of direction.

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Corresponding author. *National Institute of Fitness and Sports in Kanoya. 1 Shiromizu-cho, Kanoya, Kagoshima 891-2393, Japan.*

E-mail: nagahara@nifs-k.ac.jp

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INTRODUCTION

Basketball performance is influenced not only by tactics but also by individual technical skills and physical fitness (Drinkwater et al., 2008; Mancha-Triguero et al., 2019). In terms of physical fitness, the countermovement jump and squat jump are commonly used to assess jump ability in basketball players and have been shown to effectively differentiate players by performance level (Mancha-Triguero et al., 2019). In addition, speed and agility are considered key component of physical fitness, with 20-m sprint time and lane agility test time serving as indicators of playing level and position (Ramos et al., 2020; Stojanović et al., 2019).

To enhance above-mentioned physical fitness attributes of basketball players, previous studies have highlighted the importance of trunk muscle strength and stability—commonly referred to as core strength and stability (Luo et al., 2023; Tazji et al., 2023). For example, in 44 male adolescent basketball players, a 12-week core strength training program (including planks, deadlifts, hip lifts, kettlebell swings, etc.) improved agility performance measured by the Illinois agility test (from 23.82 s to 18.83 s, a 21% improvement) (Feng et al., 2024). Similarly, in 22 male basketball players, 8 weeks of core strength training (planks, superman, toe touches, etc.) led to an increase in vertical jump height (from 46.64 cm to 52.00 cm, a 12% improvement) (Şahiner & Koca, 2021). In another study, 10 weeks of core training (including supine buttocks raises and leg lifts) improved vertical jump hand height (from 3.05 m to 3.13 m, a 3% increase) and T-test agility performance (from 9.21 s to 8.29 s, a 10% improvement) in 30 college students (Ning, 2022).

While these studies demonstrate the positive effects of trunk strength development on physical fitness in basketball players, the training programs and outcome measures have primarily focused on static exercises (e.g., plank). However, the pelvis, as a part of the trunk, moves three-dimensionally (Nagahara et al., 2018), and pelvic list motion has been found to contribute to sprinting, jumping, and change-of-direction performance (Marshall et al., 2014; Nagahara & Murata, 2024; Pandey et al., 2021; Sado et al., 2019, 2023). Recently, a pelvic list strength test has been developed, and its results have been shown to correlate with physical fitness performance in basketball players (Maemura et al., 2025; Nagahara et al., 2025). This test measures maximal vertical force during a single-leg pelvic list motion using a force plate. Pelvic list strength has been associated with 20-m sprint speed, running jump height, and lane agility performance. These findings suggest that pelvic list strength may play an important role in physical performance. Despite this, no study has yet examined the effects of pelvic list training on physical fitness performance in basketball players.

Therefore, the purpose of this study was to investigate the effects of pelvic list training on physical fitness performance in female basketball players. Clarifying the effect of pelvic list training may contribute to the development of more effective training exercise programs in basketball.

MATERIALS AND METHODS

Experimental protocols

This study employed a two-period crossover design consisting of two 4-week training phases, separated by a 4-week washout period. Half of the participants performed pelvic list training in addition to their regular basketball training during the first 4-week phase (training period) and then completed a ladder training program—matched in volume to the pelvic list training—during the second 4-week phase (control period). The remaining participants completed the two training phases in the opposite order (i.e., ladder training first, followed by pelvic list training). The 4-week training duration was selected to align with participants' competitive schedules without interfering with their regular training routines. Pelvic list training was conducted four times per week during the designated training period. Four assessment sessions were conducted: before

and after each of the two training phases. Given the small sample size and to minimize potential period effects, a crossover design was adopted.

Participants

Seventeen female collegiate basketball players (mean $\pm$ SD: age, 19.9 ± 0.8 y; stature, 1.64 ± 0.61 m; body mass, 57.9 ± 3.7 kg) from a university team volunteered for the study. All participants were informed of the purpose, risks, and procedures involved, and provided written informed consent prior to participation. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the research ethics committee of the National Institute of Fitness and Sports in Kanoya (#23-1-57). Due to injury or illness during the experimental period, six players withdrew from the study. Ultimately, data from eleven participants (mean $\pm$ SD: age, 20.0 ± 0.9 y; stature, 1.64 ± 0.52 m; body mass, 58.5 ± 4.3 kg) were included in the final analysis.

Measurement and data processing

After a standardized warm-up, participants performed pelvic list strength test, 20-m sprint, lane agility test, pro-agility test, counter movement jump, running jump and standing long jump in a randomized order in an indoor basketball gym. The pelvic list strength test followed previously established protocols (Maemura et al., 2025; Nagahara et al., 2025). In the test, participants stood on the edge of a portable force plate (SS-FP40UD, Sports sensing, Fukuoka, Japan; 1000 Hz; length $\times$ width $\times$ height being $0.4 \text{ m} \times 0.4 \text{ m} \times 0.11 \text{ m}$) with one leg extended. From a maximally pelvic-listed position (contralateral side as low as possible), participants lifted the pelvis upward as quickly as possible. Hands were placed on the waist, and no swinging of the free leg was allowed. The peak vertical ground reaction force (GRF) was extracted from the trial. There were two conditions for the pelvic list strength test, free (without weight on the free side leg) and weighted (with 2 kg weight on the free side leg ankle) conditions. The body weight (including the weight in the weighted condition) was subtracted from the peak GRF, and the result was normalized to body mass to calculate pelvic list strength. All participants had performed the test at least five times before the study to ensure familiarity and correct execution. The researchers confirmed that the participants were able to conduct the pelvic list strength test correctly.

The 20-m sprint started from a self-selected timing in a crouched two-point stance. Sprint time was recorded using a photocell timing system (TC Timing System, Brower Timing System, Draper, UT). The photocell unit was fixed on a tripod (1-m above the ground), and the units were set at 0.5- and 20.5-m marks from the start line. The pro-agility test used three parallel tape lines (1.5 m long, 5 cm wide) spaced 5 m apart. Participants started 0.5 m behind the centre line in a crouched two-point stance and ran 5 m, turned 180° after touching the line with the outside foot, ran 10 m in the opposite direction, turned again, and ran 5 m back through the start. Time was recorded using the same photocell system. The lane agility test was performed in accordance with a previous study (Stojanović et al., 2019), with timing using the same photocell setup. The start line was set 0.5 m behind the photocell beam. Countermovement jump and running jump heights were measured using a vertical yardstick (Swift Performance Equipment, New South Wales, Australia), with results recorded to the nearest 1 cm. The standing long jump was conducted in accordance with a previous study (Bissas & Havenetidis, 2008), and jump distance was measured from the starting line to the heel of the landing foot using tape measure.

All tests were monitored by researchers, and trials were visually assessed (with video recordings for pelvic list tests). Any incorrectly performed trial was repeated. Each test was conducted twice, and the better trial was used for analysis.

Pelvic list and control training

During the training period, participants performed pelvic list exercises four times per week for four weeks. All sessions were supervised by an experimenter. The program included eight exercises (see Figure 1), summarized in Table 1. Descriptions of the exercises are as follows. Standing pelvic list: lift the pelvis rapidly from a maximally listed position (contralateral side low). Standing pelvic list with lateral leg elevation: same as above, but with added leg lift of the contralateral side. Lateral jump: start in a single-leg, crossed-leg crouched position with pelvic list, and jump laterally with emphasis on pelvic motion. Step-up with pelvic list: place one foot on a 20 cm box in a pelvic listed position (ipsilateral side high), then step up emphasizing a rapid pelvic list. Step-up forward with pelvic list: similar to above but with forward motion and leg swing. Lateral switch: start standing on one leg with the ipsilateral hand raised, then switch support leg and arm position. Hip walk: seated position, moving forward by alternating hip lifts. Hip lateral elevation on hands and knees: the participant initially on hands and knee on a floor with a straightened leg and then laterally flexed and elevated. In the control period, participants performed ladder drills (e.g., forward step, gallop, in-in-out-out, slalom, straddle hops, forward shuffle, back shuffle, stack-out, forward twist, single-leg hop), performed twice in the first two weeks and four times in the last two weeks.

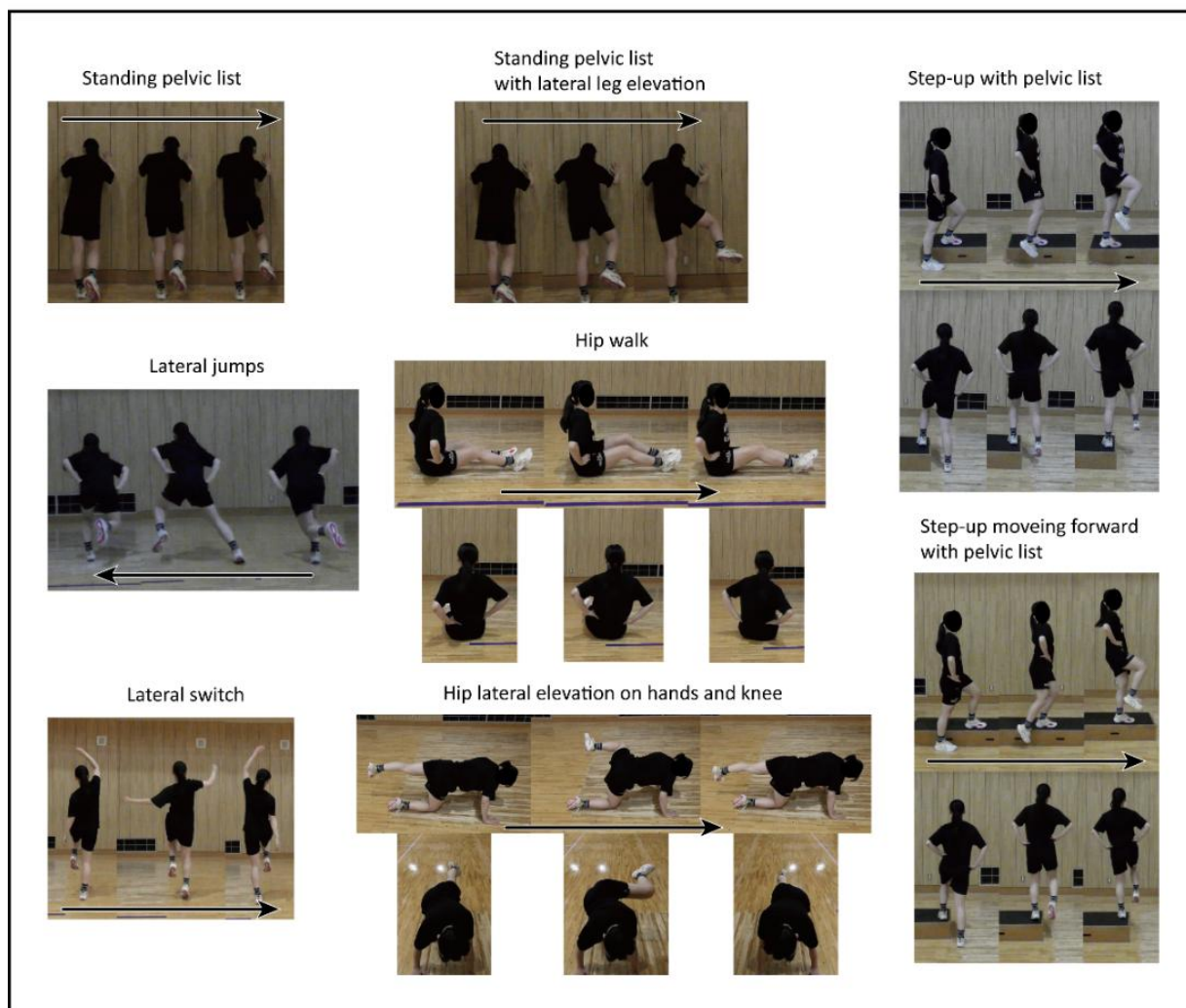


Figure 1 Pelvic list training exercises used in this study. The arrow in each exercise shows the direction of time course.

Table 1. Summary of training programs.

Exercises	1st and 2nd week	3rd and 4th week
Standing pelvic list	1s*10r for right and left	2s*10r for right and left
Standing pelvic list with lateral leg elevation	1s*10r for right and left	2s*10r for right and left
Lateral jumps	2s*10 jumps	4s*10 jumps
Step-up with pelvic list	1s*10r for right and left	2s*10r for right and left
Step-up moving forward with pelvic list	1s*10r for right and left	2s*10r for right and left
Lateral switch	2s*10 steps	4s*10 steps
Hip walk	2s*10 steps	4s*10 steps
Hip lateral elevation on hands and knee	1s*15r for right and left	2s*15r for right and left

Note. r: repetitions; s: sets.

Statistical analyses

Descriptive statistics were reported as mean $\pm$ standard deviation (SD). Changes in physical fitness variables were examined using statistics specific to the two-period crossover designs (Jones & Kenward, 2003). However, due to a technical failure during the third measurement session, pelvic list strength data were not recorded, making crossover analysis inapplicable for this variable. As a result, changes in pelvic list strength during the first training period ($n = 9$) were assessed using paired t-tests. Additionally, Pearson correlation coefficients ($n = 9$) were calculated to examine the relationship between changes in pelvic list strength and changes in other physical fitness variables. The significance threshold was set at $p < .10$ due to the reduced sample size (from 17 to 11 participants). All statistical analyses were conducted using JMP 12 (SAS Institute Japan Ltd., Tokyo, Japan).

RESULTS

Table 2 presents the changes in speed, jump and agility performance during the pelvic list training and control periods. Significant training effects were observed in the pro-agility test and lane agility test times. Table 3 summarizes the changes in pelvic list strength variables during the pelvic list training period. Significant improvements were found in right and left pelvic list strength, as well as in right-side pelvic list strength under the weighted condition, from pre- to post-training. Figure 2 illustrates the relationships between pelvic list strength variables and pro-agility test time. A significant negative correlation was observed between right pelvic list strength and pro-agility test time, indicating that greater pelvic list strength improvement was associated with greater improvement in agility performance.

Table 2. Changes in speed, agility and jump performances through pelvic list training and control training periods.

	Training period			Control period			Training effect (p-value)
	Pre training	Post training	Difference	Pre training	Post training	Difference	
20-m sprint [s]	3.46 $\pm$ 0.12	3.42 $\pm$ 0.13	-0.03 $\pm$ 0.10	3.43 $\pm$ 0.11	3.49 $\pm$ 0.11	0.06 $\pm$ 0.11	.239
Pro-agility test [s]	5.07 $\pm$ 0.15	4.96 $\pm$ 0.12	-0.11 $\pm$ 0.17	4.98 $\pm$ 0.11	5.01 $\pm$ 0.14	0.03 $\pm$ 0.14	.097
Lane-agility test [s]	12.08 $\pm$ 0.66	12.12 $\pm$ 0.61	0.04 $\pm$ 0.47	11.76 $\pm$ 0.37	12.08 $\pm$ 0.45	0.31 $\pm$ 0.31	.092
Countermovement jump height [cm]	51.6 $\pm$ 8.8	49.4 $\pm$ 7.5	-2.3 $\pm$ 3.3	51.2 $\pm$ 10.0	49.6 $\pm$ 8.1	-1.5 $\pm$ 4.2	.628
Running jump height [cm]	59.5 $\pm$ 9.4	58.5 $\pm$ 8.2	-1.1 $\pm$ 3.8	59.2 $\pm$ 7.5	58.0 $\pm$ 7.9	-1.2 $\pm$ 4.7	.475
Standing long jump distance [cm]	207.5 $\pm$ 8.9	211.2 $\pm$ 10.8	3.7 $\pm$ 7.4	206.9 $\pm$ 9.4	208.9 $\pm$ 7.3	2.0 $\pm$ 6.2	.427

Note. Bold font indicates statistically significant effect.

Table 3. Changes in pelvic list strengths through pelvic list training.

	Pre training	Post training	Difference	t-test (p-value)
Pelvic list strength right [N/kg]	4.58 ± 0.68	5.45 ± 1.00	0.87 ± 0.96	.027
Pelvic list strength left [N/kg]	4.60 ± 0.68	5.19 ± 0.79	0.59 ± 0.69	.033
Weighted pelvic list strength right [N/kg]	4.37 ± 0.55	5.60 ± 1.12	1.22 ± 0.88	.003
Weighted pelvic list strength left [N/kg]	4.91 ± 1.31	5.19 ± 1.41	0.28 ± 0.78	.311

Note. Bold font indicates statistically significant difference.

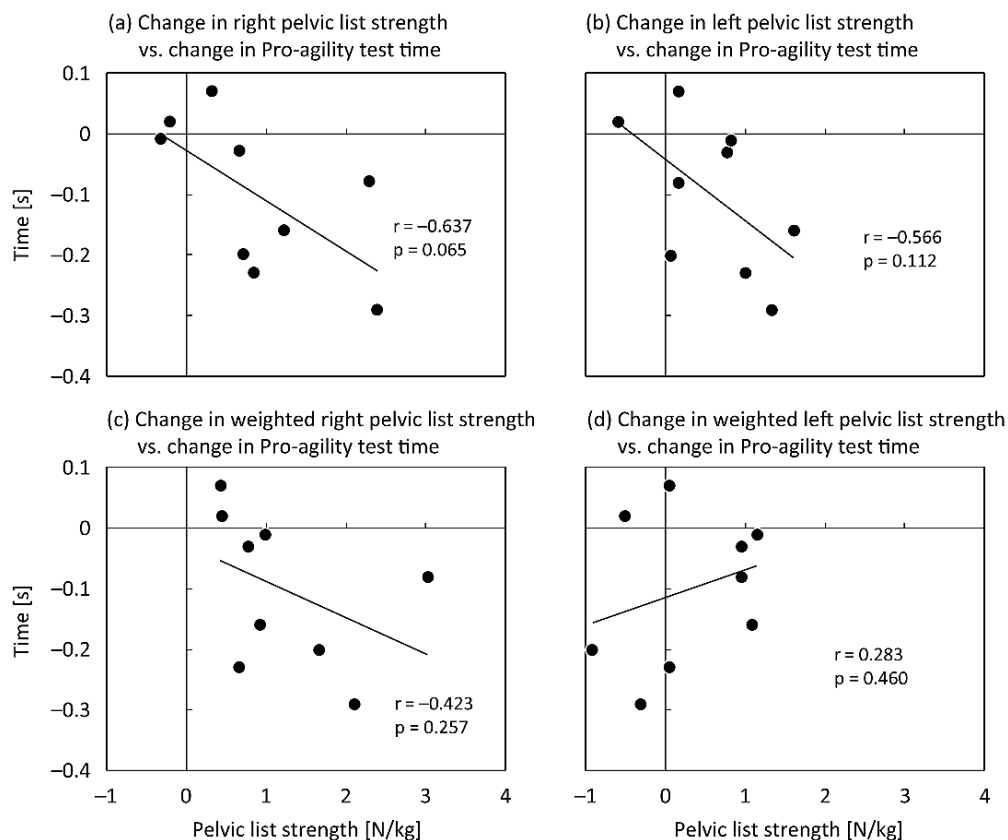


Figure 2. Relationships of changes in pelvic list strength variables and change in pro-agility test time.

DISCUSSION

This study was the first to investigate the effects of pelvic list training on pelvic list strength and other physical fitness performances in collegiate basketball players. The main findings were that there were training effects in pro-agility and lane-agility performances. Moreover, greater improvements in right pelvic list strength were correlated with greater improvements in pro-agility performance.

The 4-week pelvic list training program resulted in a trend toward greater improvements in pro-agility test time compared to the control training period (Table 2). Furthermore, the magnitude of increase in right pelvic list strength was negatively correlated with pro-agility test time (Figure 2), suggesting that improvements in pelvic list strength through targeted training may enhance agility performance in basketball players. Although lane agility test performance also showed a significant training effect (Table 2), the slight increase in test time during the pelvic list training period suggests no improvement in this measure. In contrast, lane agility performance worsened more substantially during the control (ladder training) period. The reason for this

decline remains unclear; however, it is possible that the ladder training performed during the control period may have negatively affected performance in the lane agility test. A previous cross-sectional study reported significant correlations between pelvic list strength and multiple physical fitness measures, including running jump height, 20-m sprint time, and lane agility time (Maemura et al., 2025). However, in the present intervention study, only the pro-agility test showed measurable improvement. This discrepancy may be due to the nature of the pelvic list training exercises used in this study (e.g., lateral jump, lateral switch), which emphasized a large range of pelvic motion. Such motion is particularly relevant to the change-of-direction demands in the pro-agility test (Marshall et al., 2014; Sado et al., 2019), possibly explaining the observed improvement.

As this is the first study to examine pelvic list training, there are no directly comparable studies. Furthermore, no prior research has investigated the effects of trunk (core) strength training on physical fitness specifically in adult female basketball players. One related study involving adult female athletes (volleyball and basketball) reported that 10 weeks of trunk exercise training—mainly static exercises to maintain a straight trunk—improved agility measured by the T-test, but the improvement was not correlated with lumbo-pelvic stability (Mills et al., 2005). In contrast, the current study found a correlation between improvements in pelvic list strength and agility, suggesting that dynamic pelvic list training may have a stronger and more direct influence on agility performance.

Several limitations should be noted. First, due to a technical failure during the third measurement session, pelvic list strength data were not recorded as planned, preventing the intended crossover statistical analysis for that variable. Second, six participants withdrew due to injury or illness, reducing the sample size and statistical power. Third, the training duration was limited to 4 weeks due to the athletes' competitive schedules. A longer intervention might have yielded more pronounced or consistent effects. Lastly, since the participants were all female collegiate basketball players, the generalizability of the findings to other populations (e.g., male athletes, non-athletes, other sports) remains uncertain.

CONCLUSION

In conclusion, this study demonstrates that pelvic list training can increase pelvic list strength and may contribute to improved pro-agility performance in female collegiate basketball players. These findings highlight the potential value of incorporating pelvic list exercises into strength training programs aimed at enhancing agility. The results may inform the development of more targeted and effective training protocols for basketball players, particularly in female populations.

AUTHOR CONTRIBUTIONS

K.M., H.I., K.M. and R.N., conceived and designed the experiments; K.M., H.I., K.M. and R.N., performed the experiments; K.M., H.I. and R.N., analysed the data; K.M., H.I., K.M. and R.N., wrote the paper.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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