A Survey of Static and Dynamic Stretching Protocol

Kosuke Takeuchi1*, Masatoshi Nakamura2, Hironobu Kakihana3, and Fumiko Tsukuda4

1Kobe International University, Kobe, Hyogo, Japan
ktakeuchi@kobe-kiu.ac.jp
2Niigata University of Health and Welfare, Niigata, Niigata, Japan
3Osaka Medical College, Daigaku-machi, Takatsuki, Japan
4Biwako Seikei Sport College, Otsu, Shiga, Japan
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The purpose of the present study was to investigate static stretching and dynamic stretching protocol.
138 coaches of 21 different sports completed a self-reporting questionnaire. The questionnaire was split into four sections and contained fixed-response questions. Section One identified participant demographics. The second and third sections required the participants to detail the static and dynamic stretching they used. The fourth section of the questionnaire identified how participants learned about stretching.
There were 126 coaches using static or dynamic stretching, while 12 coaches did not. Thirty-nine coaches used only static stretching, 10 coaches used only dynamic stretching, and 77 coaches used both types of stretching. The purposes of static stretching were to increase flexibility and to prevent injuries. The purposes of dynamic stretching were improvement of performance and prevention of injuries. The duration of one bout of static and dynamic stretching in a warm-up were 21.8 ± 13.2 and 22.1 ± 16.2 seconds, respectively. A common way to learn about stretching was participation in training sessions.
Coaches should use SS for a greater length of time to achieve their purposes. The results of the present study showed gaps between evidence and practice.

Keywords: static stretching, dynamic stretching, protocol

1. Introduction

Coaches commonly use static stretching (SS) and dynamic stretching (DS) as a warm-up or cool-down routine (Ebben et al., 2005). SS usually involves moving a limb to the end of its range of motion (ROM) and holding the stretched position (McHugh and Cosgrave, 2010). SS is useful for an increase in muscle extensibility (Morse et al., 2008; Nakamura et al., 2012, 2013), and for preventing injuries (Ekstrand et al., 2009). However, many previous studies showed that there are some problems of using SS before a sports activity because it decreases performance such as muscle strength (Avela et al., 2004), jump height (Cornwell et al., 2002), and sprinting (Nelson et al., 2005) through a decrease in muscle tendon unit stiffness and muscle activity (Mizuno et al., 2014). The effects of SS on muscle extensibility and performance are affected by its duration (Nakamura et al., 2013). The previous study concluded that longer SS increases muscle extensibility but decreases performance (Behm et al., 2011; Nakamura et al., 2013).

DS involves controlled movement through the active ROM (Hough et al., 2009). It is well established that DS provides an improvement of performance such as power (Manoel et al., 2008; Yamaguchi et al., 2007), sprinting (Fletcher and Anness, 2007; Little and Williams, 2006), and jumping (Holt and Lambourne, 2008; Hough et al., 2009; Jaggers et al., 2008) through an increase in body temperature (Fletcher and Jones, 2004), and muscle activation (Hough et al., 2009). The total duration has an impact on the effects of DS on performance (Behm and Chaouachi, 2011), as with SS. In addition to the improvement of performance, coaches use DS to increase muscle extensibility and for the prevention of sports related injuries. However, it is reported that muscle extensibility was not changed after DS (Mizuno, 2017). Therefore, when coaches aim to increase muscle extensibility or prevent injuries, they should use SS as a warm-up routine, while DS should be used for improving performance.

There is much evidence on the effective protocols...
of SS and DS. SS for more than 2 minutes is effective for improving muscle extensibility (Nakamura et al., 2013). DS for more than a total of 90 seconds with fast frequency is effective for improving performance (Behm and Chaouachi, 2011; Fletcher and Monte-Colombo, 2010). However, it is unclear if coaches use effective SS and DS because there are no studies that have investigated the protocols of SS and DS. Such information could be used to understand how much scientific evidence of SS and DS is understood by coaches and how to improve the gap between such evidence and practice. Therefore, the purpose of the present study was to investigate the SS and DS protocol used by coaches.

2. Materials and methods

2.1. Subjects

One hundred forty coaches registered as sport instructors of the Japan Sport Association participated in the study. They were recruited at a training session of the Japan Sport Association. They were informed of the requirements and risks associated with their involvement in this study and signed a written informed consent document. No coach or team name was associated with any responses to protect the confidentiality of the coaches. This study was approved by the ethics committee of Biwako Seikei Sport College (No. 169).

2.2. Procedure

The present study was conducted by using a self-reporting questionnaire in Japanese. The readability of the questionnaire was assessed by 5 conditioning coaches prior to use, and there was further refinement of questions.

2.3. Contents of the questionnaire

The questionnaire was split into four sections and contained fixed-response questions (Table 1), which generated categorical and ordinal data. Section One of the questionnaire identified participant demographics. The second and third sections of the questionnaire required the participants to detail the SS and DS they used. The fourth section of the questionnaire identified how participants learned about stretching. In the present study, SS and DS were defined as maintaining the muscle in a stretched position and controlled movement through a full, active range of motion, respectively. The definitions of SS and DS were explained to the participants prior to answering the questionnaire.

2.4. Statistical analyses

Data were analyzed using the IBM Statistical Package for Social Sciences (version 25) software. The significance was set at $p < 0.05$. Chi-squared tests were conducted to examine the difference of categorical and ordinal data.

Table 1  Content of questionnaire.

| Section 1 |
|-------------------|
| 1. What is/are the sports you coach? |
| 2. How long is your career as a coach? |

| Section 2s and 3 (Section 2 is about static stretching, and Section 3 is about dynamic stretching) |
|---------------------------------------------|
| 1. Do you use stretching as a warm-up or cool down routine for your athletes? |
| 2. When do you use stretching? (multiple answers possible) |
| (Warm-up/Cool-down) |
| 3. What is your purpose for using stretching? (multiple answers possible) |
| (Increase flexibility/Improve performance/Prevent injuries/Relaxation/Recovery from fatigue) |
| 4. Which is/are the targeted body part(s) for stretching? (multiple answers possible) |
| (Neck muscles/Shoulder muscles/Anterior shoulder girth muscles/Posterior shoulder girth muscles/Anterior forearm muscles/Posterior forearm muscles/Lower back muscles/Gluteus muscles/Anterior thigh muscles/Posterior thigh muscles/Medial thigh muscles/Anterior muscles of lower thigh/Calf muscles) |
| 5. How many seconds do you use stretching for? |

| Section 4 |
|-------------------|
| 1. How did you learn about stretching? |
| (Magazine/Television/Textbook/Academic paper/Training session/Internet) |
3. Results

3.1. Characteristics of the coaches

Two participants who did not complete the questionnaire were excluded from analysis. Therefore, a total of 138 questionnaires were valid for analysis. The average career of the coaches was 16.0 ± 11.4 years. There were 21 sports represented, including: softball (n = 19), tennis (n = 18), volleyball (n = 16), archery (n = 12), basketball (n = 11), baseball (n = 9), soccer (n = 9), gymnastics (n = 8), badminton (n = 5), judo (n = 5), hockey (n = 4), canoe (n = 3), swimming (n = 3), table tennis (n = 3), American football (n = 2), boxing (n = 2), golf (n = 2), wrestling (n = 2), handball (n = 2), bowling (n = 2), and rugby (n = 1).

3.2. Engagement with stretching

There were 126 coaches using SS and/or DS, while 12 coaches did not. Thirty-nine coaches used only SS, 10 coaches used only DS, and 77 coaches used both SS and DS. In total, the number of coaches using SS and DS were 116 and 87, respectively.

3.3. The purpose of stretching

The common purposes of using SS were to increase flexibility (68.1%, p < 0.05) and to prevent injuries (84.3%, p < 0.05) (Figure 1). While, the common purposes of DS were to improve performance (67.8%, p < 0.05) and to prevent injuries (73.6%, p < 0.05) (Figure 1).

3.4. Targeted body part for stretching

The common targeted body part for SS were neck muscles (62.1%, p < 0.05), shoulder muscles (75.9%, p < 0.05), posterior shoulder girdle muscles (63.8%, p < 0.05), lower back muscles (69.8%, p < 0.05), anterior thigh muscles (70.7%, p < 0.05), posterior thigh muscles (71.6%, p < 0.05), and calf muscles (81.0%, p < 0.05) (Figure 2). On the other hand, the targeted body parts for DS were shoulder girdle muscles (67.2%, p < 0.05), anterior thigh muscles (70.7%, p < 0.05), posterior thigh muscles (74.1%, p < 0.05), gluteus muscles (67.2%, p < 0.05), and calf muscles (70.7%, p < 0.05) (Figure 2).

3.5. Duration of stretching

Table 2 shows the duration of SS and DS in the warm-up. Figure 3 shows the distribution of the duration of one bout of SS and DS. Approximately 70% and 60% of the coaches use SS and DS for less than 30 seconds (Figure 3). On the other hand, approximately 10% of the coaches use SS and DS for 60 seconds or more. There was no coach who uses SS for more than 120 seconds. Table 3 shows the duration of SS and DS in the warm-up in each sport.

Figure 1 The purpose of static (n = 116) and dynamic stretching (n = 87) (multiple choice). *significantly higher values than the Chi-squared expected frequency (p < 0.05). **significantly lower values than the Chi-squared expected frequency (p < 0.05)
**Table 2** Duration of static and dynamic stretching.

|                      | Static stretching | Dynamic stretching |
|----------------------|-------------------|--------------------|
|                      | Warm-up (n = 86)  | Cool-down (n = 77) | Warm-up (n = 72) | Cool-down (n = 16) |
| Duration of one bout (sec) | 21.8 ± 13.2       | 25.8 ± 17.2        | 22.1 ± 16.2      | 23.4 ± 16.9      |
| Total duration (sec)    | 488.7 ± 345.2     | 598.0 ± 468.1      | 534.7 ± 388.6   | 492.6 ± 523.7   |

Descriptive data were mean ± SD.
Table 3  Duration of static and dynamic stretching in each sport.

|                     | Static stretching (n = 86) | Dynamic stretching (n = 72) |
|---------------------|---------------------------|-----------------------------|
|                     | Duration of one bout      | Total duration              | Duration of one bout      | Total duration              |
| Softball (n = 19)   | 18.1 ± 6.5 (n = 15)       | 516.0 ± 307.5 (n = 15)      | 25.2 ± 17.7 (n = 15)      | 613.1 ± 574.2 (n = 15)     |
| Tennis (n = 18)     | 21.4 ± 8.3 (n = 13)       | 407.1 ± 227.2 (n = 13)      | 20.2 ± 7.9 (n = 7)        | 506.3 ± 211.2 (n = 7)      |
| Volleyball (n = 16) | 20.6 ± 9.1 (n = 12)       | 563.1 ± 304.5 (n = 12)      | 25.7 ± 23.7 (n = 8)       | 735.0 ± 711.2 (n = 8)      |
| Archery (n = 12)    | 23.0 ± 16.4 (n = 11)      | 338.2 ± 213.4 (n = 11)      | 13.3 ± 8.3 (n = 5)        | 276.0 ± 192.6 (n = 5)      |
| Basketball (n = 11) | 23.3 ± 22.2 (n = 3)       | 520.0 ± 138.6 (n = 3)       | 16.4 ± 6.9 (n = 7)        | 771.4 ± 543.8 (n = 7)      |
| Baseball (n = 9)    | 16.9 ± 8.0 (n = 5)        | 660.0 ± 369.9 (n = 5)       | 15.6 ± 7.8 (n = 7)        | 667.5 ± 597.8 (n = 7)      |
| Soccer (n = 9)      | 29.0 ± 22.3 (n = 4)       | 420.0 ± 213.5 (n = 4)       | 12.2 ± 3.0 (n = 5)        | 480.0 ± 164.3 (n = 5)      |
| Others (n = 44)     | 24.1 ± 12.4 (n = 23)      | 520.8 ± 305.2 (n = 23)      | 28.6 ± 18.9 (n = 18)      | 334.7 ± 225.8 (n = 18)     |

Descriptive data were mean ± SD.

3.6. How coaches learn about stretching

The common way for coaches to learn about stretching was participation in training sessions (78.1 %, p < 0.05) (Figure 4). There were a few coaches who used magazines (32.8%, p > 0.05), television (18.0%, p > 0.05), academic papers (14.1%, p > 0.05), and the Internet (21.9%, p > 0.05) (Figure 4).

3.7. Reasons not to use stretching

Twelve coaches did not use any stretching protocol. The reasons for not using any stretching were: having no time to use it (n = 9), leaving conditioning up to their athletes (n = 2), and having no experience of using stretching (n = 1).

4. Discussion

The present study showed that 116 and 87 of 138 coaches (84.1% and 63.0%, respectively) used SS and DS as a warm-up or cool-down routine. The duration of one bout of SS is approximately 20 seconds in each sport. A previous study reported that 31 and 22 of 32 rower coaches (96.9% and 68.8%, respectively) used SS and DS in their conditioning practice (Gee et al., 2011). In addition, many previous studies reported that SS for between 10 and 20 seconds was used in American professional sports (Ebben et al., 2004; Ebben et al., 2005b; Simenz et al., 2005). These data indicated that the results of the present study are consistent with the previous studies.
The main purpose of using SS was prevention of injuries, followed by an increase in flexibility. The targeted body parts of SS were Neck muscles, Shoulder muscles, Posterior shoulder girth muscles, Lower back muscles. Anterior thigh muscles, Posterior Thigh muscles, and Calf muscles. In softball, tennis and volleyball for which there were a large number of coaches in this study, it was reported that the injury rate of shoulder injuries, low back pain, and muscle strain of the lower extremity were high (Krajnik et al., 2010; Marks et al., 1988; Nhan et al., 2018). These data indicated that the targeted body part of SS is a part with a high risk of injuries. However, previous studies reported that SS before sports activities shows no overall effect on all-cause injuries or overuse injuries (Pope et al., 1998, 2000; van Mechelen et al., 1993). It is possible that SS could prevent acute muscle injuries in movements with repetitive contraction, such as muscle strain (Amako et al., 2003; Ekstrand et al., 1983; Hadala and Barrios, 2009). Therefore, it may be important to increase muscle extensibility, because SS could prevent muscle injuries. Previous studies reported that SS for more than 2 minutes is effective for an increase in muscle extensibility of the gastrocnemius (Nakamura et al., 2013). The results of the present study showed that coaches used SS for approximately 20 seconds for the gastrocnemius, and no coach used SS for more than 2 minutes. These findings suggested that it is better for coaches to use SS for a longer time to achieve their purpose of SS. SS for more than 30 seconds decreases performance such as muscle strength and jump performance (Behm and Chaouachi, 2011). The decrease in muscle strength of the triceps surae is restored within 10 minutes (Mizuno et al., 2014). Therefore, coaches should avoid using SS immediately before competition.

The main purpose of DS was prevention of injuries, followed by improvement of performance. To our best knowledge, there have been no studies to examine whether DS is effective in prevention of injuries. It is possible that a sports specific warm-up including DS could prevent injuries (Kiani et al., 2010). However, it cannot be determined whether DS is effective for preventing injuries or not, because a sports specific warm-up includes various programs such as stability exercises, balance exercises, and DS (Kiani et al., 2010). The effects of DS on injury prevention needs to be further studied because it was given as the main purpose of DS. Many previous studies reported that DS improves various types of performance, such as power (Manoel et al., 2008; Yamaguchi et al., 2007), sprinting (Fletcher and Anness, 2007; Little and Williams, 2006), and jumping (Holt and Lambourne, 2008; Hough et al., 2009; Jaggers et al., 2008). A review by Behm reported that DS for a total of more than 90 seconds was effective on peak force, and power improvement less than 90 seconds (Behm and Chaouachi, 2011). The results of the present study showed that the average total duration of DS was approximately 500 seconds, which indicated that DS could improve performance. Approximately 50% of the coaches used DS to increase flexibility, but it was not a significant percentage. Mizuno et al. (Mizuno, 2017) examined the effects of DS on flexibility and showed that DS increased ROM without changing the mechanical properties of the muscle, which was changed after SS. Therefore, when coaches aim to increase muscle extensibility and prevent muscle injuries, they should choose to use SS rather than DS. On the other hand, when coaches aim to improve performance, they should use DS as a warm-up.

The results of the present study showed that approximately 77 of 138 coaches (55.8%) used both SS and DS. There have been limited studies examining the effects of a combination of SS and DS (Loughran et al., 2017b). Loughran et al. examined the effects of a combined static-dynamic stretching protocol on performance in elite Gaelic footballers, and showed that DS prior to SS nullifies the performance deficits caused by SS (Loughran et al., 2017b). Zakaria et al. compared the effects of SS + DS and SS on prevention of injuries in high school soccer players, and showed that there was no significant difference in occurrence of injuries (Loughran et al., 2017a). Therefore, there was no negative effects of combined use of SS and DS on prevention of injuries. These previous studies suggested that a combination of SS and DS could complement each disadvantage. However, there have been limited studies to examine the effects of the combination of SS and DS. A traditional warm-up consists of three steps involving an aerobic exercise, SS, and dynamic activity including DS (Behm and Chaouachi, 2011). Future research should examine the combination effect of aerobic exercise, SS and DS.

The present study revealed that there were some gaps between evidence of stretching and practice.
Researchers have not built evidence on what a coach needs. In addition, coaches have not been able to use evidence effectively. To fill such gaps, how coaches learn about stretching was examined. The results showed that coaches learn by participation in training sessions, and it indicated that researchers should convey evidence at training sessions rather than at conference presentations and via papers, to fill in the gaps in knowledge.

In this study, 9 of 12 coaches did not use any stretching protocol because of not having enough time to use one. To increase muscle extensibility, the duration of one bout of SS requires at least 2 minutes (Nakamura et al., 2013). It may be difficult to use SS for 2 minutes because time for practice is limited. It has been reported that SS with heat modality could improve flexibility more than SS alone in healthy people (Nakano et al., 2012). Shorter duration stretching methods, such as a combination of heat modalities, should be examined.

There were some limitations in this study. The coaches were registered as sport instructors of the Japan Sport Association and were recruited at a training session. The training session was not related to any stretching protocols, but it was possible that there was some bias in the results about how coaches learn about stretching. The present study revealed the overall characteristics of stretching protocols. However, it was possible that the purposes and protocols of stretching were different among coaches depending on their sports. The results of the present study were analyzed without grouping according to characteristics of each sport because of the sample size. Future research should investigate the stretching protocols for each sport to develop better stretching programs matched for characteristics of each sport. It is also possible that despite our best efforts to maximize the readability of the survey, some questions may have been misinterpreted, thus producing inaccurate data. Similarly, there is also the potential that some recall bias may exist within the responses to retrospective self-reporting questions.

5. Conclusion

The present study investigated SS and DS protocols and showed gaps between evidence and practice. Coaches should use SS for a greater length of time to archive their purposes. Researchers should build evidence on the prevention of injuries by DS and the combination effects of aerobic exercise, SS and DS.

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References

Amako, M., Oda, T., Masuoka, K., Yokoi, H., and Campisi, P. (2003). Effect of static stretching on prevention of injuries for military recruits. Mil. Med., 168 (6): 442-446.

Avela, J., Finni, T., Liikavainio, T., Niemelä, E., and Komü, P. V. (2004). Neural and mechanical responses of the triceps surae muscle group after 1 h of repeated fast passive stretching. J. Appl. Physiol., 96: 2325-2332.

Behm, D. G. and Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. Eur J. Appl. Physiol., 111: 2633-2651.

Cornwell, A., Nelson, A., and Sidaway, B. (2002). Acute effects of stretching on the neuromechanical properties of the triceps surae muscle complex. Eur. J. Appl. Physiol., 86: 428-434.

Ebben, W. P., Carroll, R. M., and Simenz, C. J. (2004). Strength and Conditioning Practices of National Hockey League Strength and Conditioning Coaches. J. Strength Cond. Res., 18: 889-897.

Ebben, W. P., Hintz, M. J., and Simenz, C. J. (2005a). Strength and conditioning practices of Major League Baseball strength and conditioning coaches. J. Strength Cond. Res., 19: 538-546.

Ebben, W. P., Hintz, M. J., and Simenz, C. J. (2005b). Strength and Conditioning Practices of Major League Baseball Strength and Conditioning Coaches. J. Strength Cond. Res., 19: 538-546.

Ekstrand, J., Gillquist, J., and Liljedahl, S. O. (1983). Prevention of soccer injuries. Supervision by doctor and physiotherapist. Am. J. Sport Med., 11: 116-120.

Fletcher, I. M. and Anness, R. (2007). The acute effects of combined static and dynamic stretch protocols on fifty-meter sprint performance in track-and-field athletes. J. Strength Cond. Res., 21: 784-787.

Fletcher, I. M. and Jones, B. (2004). The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. J. Strength Cond. Res., 18: 885-888.

Fletcher, I. M. and Monte-Colombo, M. M. (2010). An investigation into the possible physiological mechanisms associated with changes in performance related to acute responses to different preactivity stretch modalities. Appl. Physiol. Nutr. Metab., 35: 27-34.

Gee, T. I., Olsen, P. D., Berger, N. J., Golby, J., and Thompson, K. G. (2011). Strength and Conditioning Practices in Rowing. J. Strength Cond. Res., 25: 668-682.

Hadala, M. and Barrios, C. (2009). Different strategies for sports injury prevention in an America’s Cup yachting crew. Med. Sci. Sports Exerc., 41: 1587-1596.

Holt, B. W. and Lambourne, K. (2008). The impact of different warm-up protocols on vertical jump performance in male collegiate athletes. J. Strength Cond. Res., 22: 226-229.

Hough, P. A., Ross, E. Z., and Howatson, G. (2009). Effects
of Dynamic and Static Stretching on Vertical Jump Performance and Electromyographic Activity. J. Strength Cond. Res., 23: 507-512.

Jaggers, J. R., Swank, A. M., Frost, K. L., and Lee, C. D. (2008). The acute effects of dynamic and ballistic stretching on vertical jump height, force, and power. J. Strength Cond. Res., 22: 1844-1849.

Kiani, A., Hellquist, E., Ahlqvist, K., Gedeborg, R., Michäelsson, K., and Byberg, L. (2010). Prevention of soccer-related knee injuries in teenage girls. Arch Intern Med., 170: 43-49.

Krajnik, S., Fogarty, K. J., Yard, E. E., and Comstock, R. D. (2010). Shoulder injuries in US high school baseball and softball athletes, 2005-2008. Pediatrics, 125: 497-501.

Little, T. and Williams, A. G. (2006). Effects of differential stretching protocols during warm-ups on high-speed motor capacities in professional soccer players. J. Strength Cond. Res., 20: 203-207.

Loughran, M., Glasgow, P., Bleakley, C., and McVeigh, J. (2017a). The effects of a combined static-dynamic stretching protocol on athletic performance in elite Gaelic footballers: A randomised controlled crossover trial. Phys. Ther. Sport., 25: 47-54.

Loughran, M., Glasgow, P., Bleakley, C., and McVeigh, J. (2017b). The effects of a combined static-dynamic stretching protocol on athletic performance in elite Gaelic footballers: A randomised controlled crossover trial. Phys. Ther. Sport., 25: 47-54.

Manolli, M. E., Harris-Love, M. O., Danoff, J. V., and Miller, T. A. (2008). Acute effects of static, dynamic, and proprioceptive neuromuscular facilitation stretching on muscle power in women. J. Strength Cond. Res., 22: 1528-1534.

Marks, M. R., Haas, S. S., and Wiesel, S. W. (1988). Low back pain in the competitive tennis player. Clin. Sports Med., 7: 277-287.

McHugh, M. P. and Cosgrave, C. H. (2010). To stretch or not to stretch: the role of stretching in injury prevention and performance. Scand. J. Med. Sci. Sports, 20: 169-181.

Mizuno, T. (2017). Changes in joint range of motion and muscle-tendon unit stiffness after varying amounts of dynamic stretching. J. Sports Sci., 35: 2157-2163.

Mizuno, T., Matsumoto, M., and Umemura, Y. (2014). Stretching-induced deficit of maximal isometric torque is restored within 10 minutes. J. Strength Cond. Res., 28, 147-153.

Morse, C. I., Degens, H., Seynnes, O. R., Maganaris, C. N., and Jones, D. A. (2008). The acute effect of stretching on the passive stiffness of the human gastrocnemius muscle tendon unit. J. Physiol., 586: 97-106.

Nakamura, M., Ikezoe, T., Takeno, Y., and Ichihashi, N. (2012). Effects of a 4-week static stretch training program on passive stiffness of human gastrocnemius muscle-tendon unit in vivo. Eur. J. Appl. Physiol., 112: 2749-2755.

Nakamura, M., Ikezoe, T., Takeno, Y., and Ichihashi, N. (2013). Time course of changes in passive properties of the gastrocnemius muscle-tendon unit during 5 min of static stretching. Man. Ther., 18: 211-215.

Nakano, J., Yamabayashi, C., Scott, A., and Reid, W. D. (2012). The effect of heat applied with stretch to increase range of motion: A systematic review. Phys. Ther. Sport., 13: 180-188.

Nelson, A. G., Driscoll, N. M., Landin, D. K., Young, M. A., and Schexnayder, J. C. (2005). Acute effects of passive muscle stretching on sprint performance. J. Sport. Sci., 23: 449-454.

Nhan, D. T., Klyce, W., and Lee, R. J. (2018). Epidemiological Patterns of Alternative Racquet-Sport Injuries in the United States, 1997-2016. Orthop. J. Sports Med., 6: 232596711878623.

Pope, R., Herbert, R., and Kirwan, J. (1998). Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. Aust. J. Physiother., 44: 165-172.

Pope, R. P., Herbert, R. D., Kirwan, J. D., and Graham, B. J. (2000). A randomized trial of preexercise stretching for prevention of lower-limb injury. Med. Sci. Sports Exerc., 32: 271-277.

Simenz, C. J., Dugan, C. A., and Ebben, W. P. (2005). Strength and Conditioning Practices of National Basketball Association Strength and Conditioning Coaches. J. Strength Cond. Res., 19: 495.

van Mechelen, W., Hlobil, H., Kemper, H. C. G., Voorn, W. J., and de Jongh, H. R. (1993). Prevention of running injuries by warm-up, cool-down, and stretching exercises. Am. J. Sport Med., 21: 711-719.

Yamaguchi, T., Ishii, K., Yamanaka, M., and Yasuda, K. (2007). Acute Effects of Dynamic Stretching Exercise on Power Output During Concentric Dynamic Constant External Resistance Leg Extension. J. Strength Cond. Res., 2: 1238.

Name: Kosuke Takeuchi

Affiliation: Kobe International University, Faculty of Rehabilitation, Department of Physical Therapy

Address: 9-1-6 Koyocho-naka, Higashinada-ku, Kobe, Hyogo 658-0032

Japan

Brief Biographical History: 2017 Assistant professor in Kobe International University

Main Works:
• Kosuke Takeuchi, Masahiro Takemura, Masatoshi Nakamura, Fumiko Tsukuda, Shumpi Miyakawa. Effects of active and passive warm-ups on range of motion, strength, and muscle passive properties in ankle plantar-flexor muscles. J. Strength Cond. Res., in press.
• Kosuke Takeuchi, Masahiro Takemura, Toshihiko Shimono, Shumpi Miyakawa. Baseline muscle tendon unit stiffness does not affect static stretching of the ankle plantar flexor muscles. J. Phys. Ther. Sci., 30: 1377-1380, 2018.

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