Temporal efficacy of kinesiology tape vs. traditional stretching methods on hamstring extensibility

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ABSTRACT

Background: The epidemiology and aetiology of hamstring injuries in sport have been well documented. Kinesiology tape has been advocated as a means of improving muscle flexibility, with potential implications for injury prevention. ***Purpose:*** To compare the temporal pattern of efficacy of kinesiology tape and traditional stretching techniques on hamstring extensibility. ***Study Design:*** Controlled laboratory study. ***Methods:*** Thirty recreationally active male participants (Mean ± SD: age 21.0 ± 0.1 years; height 180 ± 6 cm; mass 79.4 ± 6.9 kg) completed an active knee extension assessment (of the dominant leg) as a measure of hamstring extensibility. Three experimental interventions of equal time duration were applied in randomized order: Kinesiology tape (KT), static stretch (SS), proprioceptive neuromuscular facilitation (PNF). Measures were taken at baseline, +1, +10 and +30 mins after each intervention. The temporal pattern of change in active knee extension was modelled as a range of regression polynomials for each intervention, quantified as the regression coefficient. ***Results:*** With baseline scores not statistically different between groups, and baseline AKE set at 100%, PNF showed a significant improvement immediately post-intervention (PNF_{+1} = 107.7 ± 8.2%, p = .01). Thereafter, only KT showed significant improvements in active knee extension (KT_{+10} = 106.0 ± 7.1%, p = .05; KT_{+30} = 106.9 ± 5.0%, p = .02). The temporal pattern of changes in active knee extension after intervention was best modelled as a positive quadratic for KT, with a predicted peak of 108.8% baseline score achieved at 24.2 mins. SS was best modelled as a negative linear function, and PNF as a negative logarithmic function, reflecting a rapid decrease in active knee extension after an immediate positive effect. ***Conclusion:*** Each intervention displayed a unique temporal pattern of changes in active knee extension. PNF was best suited to affect immediate improvements in hamstring extensibility, whereas kinesiology tape offered advantages over a longer duration. ***Clinical Relevance:*** The logistics of the sporting or clinical context will often dictate the delay between intervention and performance. Our findings have implications for the timing and choice of intervention aimed at increasing hamstring extensibility in relation to performance.

Level of Evidence: 2c

Keywords: flexibility, hamstring, kinesiology tape, stretching

INTRODUCTION

The incidence and recurrence of hamstring injuries in sport have been well documented, leading to calls for a review of injury prevention strategies.[1-4] Although many biomechanical and physiological components can influence the occurrence, one “modifiable” risk factor that is commonly discussed is muscle flexibility.[1-6] Greater hamstring flexibility has been associated with reduced injury incidence in sporting and military populations.[7,8] Traditionally musculoskeletal stretching protocols adopted a static stretching approach, more recently linked to detrimental effects on strength and power and advocated only as an outcome measure.[9] Alternative methods such as active, isometric contractions and the use of proprioceptive neuromuscular facilitation (PNF) techniques have subsequently been considered and used to treat a broad range of orthopaedic conditions.[10] The brief isometric contraction creates a reduction in muscle tension and subsequently enables range of movement (ROM).[11]

A more recent development within the clinical setting theorizing similar physiological mechanisms is the application of kinesiology taping (KT), creating a pulling force on the skin in order to attempt to enable and enhance ROM. However there remains little empirical evidence for its support. Only 22% (of 72 studies) reported immediate positive results for the use of KT on muscle extensibility,[12] with methodological variations in application, anatomical regions, recruitment criteria and sample size limiting direct comparisons between studies.

The temporal efficacy of intervention techniques on muscle extensibility has been afforded little consideration, despite the implications for sporting performance and the clinical environment. Immediate change in muscle extensibility post-intervention is likely to be through increased stretch tolerance, pain gate theory, reciprocal or autogenic inhibition. Thus static stretching and PNF would have an acute effect on hamstring extensibility, with PNF expected to show greater gains due to the increased contraction. However over a period of 30 minutes it would be expected that KT would show the greater effect as the properties of the tape are activated. Since tape is applied from the origin to insertion through the muscle stretch it could be hypothesized that through prolonged stress relaxation and visoelastic deformation, applying a constant force over a period of time (creep) will increase tissue extensibility. Although it is suggested that improving hamstring extensibility decreases the injury risk, the efficacy of the improvement over time is vital to ensure the extensibility is maintained through training and performance. The aim of the present study was to compare the immediate, 10 minute and 30 minute post-intervention efficacy of KT to traditional stretching techniques on hamstring extensibility to assist practitioners in choice of intervention. It was hypothesized that the temporal pattern of changes in hamstring extensibility will be unique to each intervention, given their discrete mechanistic influence.

METHODS

30 male participants (Mean ± SD: age 21.0 ± 0.1 years; height 180 ± 6 cm; mass 79.4 ± 6.9 kg) completed the present study, with inclusion criteria requiring that each participant be male between the ages of 18-22 years, participating in recreational sport four times a week, asymptomatic from injury and with no history of previous hamstring injury. Exclusion criteria included history of lumbar or neurological symptoms, history of musculoskeletal disorders or injuries within the previous 12 months, medical conditions that may have altered muscle flexibility and skin allergies or conditions. All participants were further screened and excluded if their straight leg raise was < 70°. The 30 participants were randomly and evenly selected into 3 groups defining the nature of the intervention: static stretch (SS), PNF and KT. Detailed information regarding the nature and purpose of the study was provided, and all participants provided written informed consent in accordance with the departmental and university ethical procedures and following the principles outlined in the Declaration of Helsinki.

Data Collection & Analysis

All participants completed a standardized five minute warm up on the cycle ergometer.[13] Five centimeter seat belts were placed across ASIS and the non-dominant leg at 20cm above tibial tuberosity to stabilize participants during the standardized Active Knee Extension (AKE) position.[14,15] The hip was placed in to 90^0 and fixed using a seat belt, proximal to the popliteal crease (Figure 1). All belts were marked for remeasurement, and the dominant leg was measured for all participants.

** Figure 1 near here **

The measurement of AKE was taken once the participant had actively extended the knee to their point of hamstring stretch tolerance (no pain and initial resistance) and at that point the calcaneus was supported to allow a baseline measurement to be recorded, via a standard goniometer (Myrin, Patterson Medical, North Ryde, Australia) at the tibial tuberosity.[16,17] The participant was then placed prone on the plinth with a pillow under the ankles to assist in relaxation of hamstrings. Subsequent to this baseline measure, AKE measurements were completed immediately, 10 minutes and 30 minutes post intervention. In SS the group barrier of resistance was found in AKE and a 30 sec hamstring stretch applied, with a 10 sec rest period between each stretch, repeated three times.[18,19] The PNF group was placed in AKE position and the initial stretch barrier held for 10 secs, prior to 10 secs PNF contract-relax resistance of 75%. There was a three second release from barrier prior to stretching to new resistance barrier for 10 secs, and this process was repeated three times.[20] For the SS and PNF interventions the time of active implementation was standardised, and this same time (5 minutes total) duration was used in the KT intervention. For KT application the distributor's guidelines were followed, with the area prepared and a single Y-cut application at 25% stretch, applied from origin at ischial tuberosity to insertion at head of fibula, and medial condyle of tibia to hamstring muscle insertion points (Figure 2). For all participants and for each intervention, all procedures were performed by the same therapist.

** Figure 2 near here **

Statistical Analysis

The aim was to describe the temporal nature of improvements in hamstring extensibility post-intervention. A range of regression polynomials were applied to each intervention in order to quantify the strength of fit, and determine the optimum model to best describe temporal efficacy. The strength of the regression was determined using the r^2 value. All statistical assumptions associated with the statistical methods above were explored. The statistical analyses were calculated using SPSS for Windows, version 18.0 (SPSS, Inc., Chicago, IL, USA). Data are presented as mean ± standard deviation. Time subscripts are used to specify the measurement time as baseline "00", immediately post-intervention "+1", 10 minutes post-intervention "+10", and 30 minutes post-intervention "+30". Thus an immediate post-intervention measure following the PNF intervention would be described as PNF_{+1}.

RESULTS

ANOVA confirmed no significant differences in AKE between the three groups at baseline. With the baseline score for each subject is set to 100%, repeated measures ANOVA revealed a significant interaction between time and intervention (Figure 3). Active knee extension scores at PNF_{+1} (107.7 ± 8.2%, $p = .01$), KT_{+10} (106.0 ± 7.1%, $p = .05$) and KT_{+30} (106.9 ± 5.0%, $p = .02$) were significantly higher than pre-intervention measures.

** Figure 3 near here **

To investigate the temporal pattern of changes in active knee extension with each intervention, a linear regression was initially conducted for each intervention. The regression equations used to predict active knee extension (AKE) from time after intervention (t) are summarized as follows:

KT: $AKE = 99.84 + 0.35t$ $\quad r^2 = 0.71$, $p = 0.01$

SS: $AKE = 105.06 – 0.40t$ $\quad r^2 = 0.82$, $p = 0.01$

PNF: $AKE = 111.75 – 0.43t$ $\quad r^2 = 0.66$, $p = 0.01$

Subsequent to a forced linear regression, the polynomial was altered for each condition to investigate the optimum model to fit the changes in AKE with time after intervention. The strength of the regression was used as the parameter to select the optimum function. The best fit for each intervention is shown diagrammatically in Figure 4 and the regression equations are summarized as:

KT: Quadratic $\quad AKE = 99.14 + 0.80t – 0.02t^2$ $\quad r^2 = 0.76$

SS: Linear $\quad AKE = 105.06 – 0.40t$ $\quad r^2 = 0.82$

PNF: Logarithmic $\quad AKE = 115.16 – 4.25\ln(t)$ $\quad r^2 = 0.77$

** Figure 4 near here **

DISCUSSION

The current study investigated the efficacy of traditional stretching techniques and kinesiology tape on hamstring extensibility over a 30-minute period. Contemporary reviews have found only a minimal number of studies, many of low methodological quality, with KT providing no significant difference to other interventions.[12] However, the temporal nature of the benefits afforded by kinesiology tape have not been considered.

Only kinesiology tape demonstrated a positive linear correlation with time post-intervention. Both static stretching and PNF demonstrated a negative relationship with time, such that hamstring extensibility gradually decreased after an initial improvement. This finding has implications for the practitioner, since the choice of intervention might depend on the time constraints of the context. If immediate and short-term improvements in hamstring flexibility are required then these findings suggest that PNF is the preferable application, consistent with previous literature.[20] However, if improvement is required over a greater time period then kinesiology tape offers potential benefits.

Few studies have considered the temporal influence of these interventions, more commonly considering only the immediate effects after an application.[21,22] The positive influence of KT supports previous literature,[23,24] but the temporal pattern of changes in hamstring extensibility following the KT application was best modelled with a quadratic function. The predictive quadratic equation yields a maximum active knee extension score of 108.8% of baseline measure at 24.2 min post-application. Further analysis of the predictive quadratic curve shows that AKE is raised to 105% of baseline by 9 min post-intervention. Therefore a window of opportunity of approximately 30 min exists (from +9 to +39 mins post-intervention) where AKE is greater than 105% of baseline.

The proposed physiological mechanism is complex and incompletely understood, with the majority of studies theorizing four main mechanisms to that lead to the decrease in muscle tension and increased ROM; autogenic inhibition, reciprocal inhibition, stress relaxation, and pain gate control theory.[25] The current findings suggest that the immediate change in muscle extensibility is likely to be through either increased stretch tolerance, pain gate theory, reciprocal or autogenic inhibition. The greatest initial gains attributed to PNF advocate increased co-contraction theory, with beneficial effects on surrounding anatomical structures in addition to the muscle isolated for contraction. Stress relaxation with viscoelastic deformation of tissue or reciprocal inhibition with contraction of the agonist and antagonist may be plausible theories.[26] However the pain gate control theory may be the most plausible, with the muscle stretched forcefully into a new end of range the golgi tendon organs are activated in an attempt to reduce injury. [27] As the tendons are stretched the muscle is contracted in a lengthened position, inhibiting pain, and potentially enabling the golgi tendon organs to adapt to the new force threshold and achieve an increase in length. The current results demonstrating a negative correlation with time for SS and PNF suggest that if viscoelastic change has occurred this is short term and is unable to be maintained. This supports previous observations that post PNF intervention, muscle activity returned to 50% within one second and 90% in 10 seconds.[28]

The current findings that KT was the preferential intervention over 30 minutes supports the proposal that KT must be applied prior to use to allow the glue properties of the tape to activate. As tape is applied to the skin, it could be hypothesized that any increase in tissue extensibility might be due to cutaneous receptor response influencing the effects of stress relaxation and viscoelastic deformation by applying a constant force over a period of time (creep). The adaptive change in tissue might be due to either increased circulation in the taped area or stimulation of the cutaneous mechanoreceptors to assist in tissue deformation.[29] The optimum post-intervention time derived from the regression equation appears to be 24.2 mins, suggesting a combination of initial cutaneous mechanoreceptor stimulation and viscoelastic change that may assist in deformation over time. The mechanisms underpinning stretch tolerance and the influence of sensory neural pathways remain unclear. Changing muscle extensibility can increase the number of sarcomeres and stimulate the rearrangement of collagen through adaptive change and deformation of tissue.[30]

The current study used healthy, recreationally active male participants, kinesiology tape is increasingly popular to assist in prevention, technique improvement and performance facilitation.[31] It must also be considered that an increase in muscle extensibility may be detrimental to power and performance, and may actually increase injury risk.[2,32] The current findings cannot be generalized to a wider population according to age, gender and health of the subjects. The findings are also specific to the nature of the interventions, and the measure of active knee extension. In this respect further research is encouraged to explore both the potential benefits of kinesiology tape, and the physiologic explanatory mechanisms. Electromyographical analysis of the muscular response would further develop the understanding of the mechanistic influence of kinesiology tape. Furthermore, any observed changes in the contractile properties of the hamstring musculature are likely to have an ipsilateral influence on the quadriceps for example. Changes in the hamstring:quadriceps strength ratio would subsequently influence the dynamic control ratio of the knee joint. Lower limb mechanics are therefore likely to be influenced more generally by localized changes to the hamstrings. Likewise, the function of the hamstrings is likely to influence changes in the gluteal and core musculature via the posterior chain. The benefits of kinesiology tape are likely to be influenced by a range of extrinsic factors to include the environment, nature of injury, population, sporting demands, physiological, psychological, and biomechanical characteristics, as well as therapist experience. Efficacy will also be directly related to the execution of the techniques; duration, intensity, and reliability of application.[28] Future studies should consider longitudinal studies, assessment of effects on additional muscle groups, functional task assessment, and alternative tape application methods.

CONCLUSION

This study has modelled the temporal changes in active knee extension to contrast the efficacy of kinesiology tape, static stretching, and PNF. The choice of intervention should consider the temporal context of the scenario. For an immediate improvement in hamstring extensibility PNF is preferable, but for advantages over a longer duration (up to 30 minutes in this study) kinesiology tape is advantageous. The optimum timing of kinesiology tape application was 24 minutes prior to assessment of hamstring extensibility.

REFERENCES

1. Liu H, Garrett WE, Moorman C, et al. (2012) Injury rate, mechanism, and risk factors of hamstring strain injuries in sports: A review of the literature. *J Sport Health Sci*. 2012;1(2):92-101.
2. Folpp H, Deall S, Harvey LA, et al. Can apparent increases in muscle extensibility with regular stretch be explained by changes in tolerance to stretch. *Austral J Physiother.* 2006;52:45-50.
3. Peterson J, Holmich P. Evidence based prevention of hamstring injuries in sport. *B J Sports Med.* 2005;39:319-323.
4. Brooks JHM, Fuller CW, Kemp SPT, et al. Incidence, risk and prevention of hamstring muscle injuries in professional rugby union. *Am J Sports Med*. 2006;34(8):1297-1306.
5. Bahr R, Holme I. Risk factors for sports injuries – a methodological approach. *Br J Sports Med*. 2003;37:384-392.
6. Alonso J, McHugh MP, Mullaney MJ, et al. Effect of hamstring flexibility on isometric knee flexion angle torque relationship. *Scand J Med Sci Sports*. 2009;19:252-256.
7. Witvrouw E, Danneels L, Asselman P, et al. Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players: a prospective study. *Am J Sports Med.* 2003;31(1):41-46.
8. Hartig D, Henderson JM. Increasing hamstring flexibility decreases lower extremity overuse injuries in military basic trainees. *Am J Sports Med*. 1999;27(2):173-176.

9. Young W, Clothier P, Otago L, et al. Acute effects of static stretching on hip flexor and quadriceps flexibility, range of motion and foot speed in kicking a football. *J Sci Med Sports*. 2004;7:23-31.
10. Adler SS, Beckers D, Buck, M. *PNF in Practice. An illustrated Guide*. 2nd Revised Ed. Hiedeleberg, Germany: Springer Medizin; 2003.
11. Nelson RT, Bandy WD. Eccentric training and static stretching improve hamstring flexibility of high school males. *J Athl Train*. 2004;39:254-258.
12. Williams S, Whatman C, Hume PA, et al. Kinesiotaping in treatment and prevention of sports injuries. A meta analysis of the evidence for its effectiveness. *Sports Med*. 2012;42(2):153-164.
13. Bradley PS, Olsen PD, Portas MD. The effect of static, ballistic and proprioceptive neuromuscular facilitation on vertical jump performance. *J Strength Cond Res*. 2007;7(1):223-226.
14. Mendiguchia J, Brughelli M. A return to sport algorithm for acute hamstring injuries. *Phys Ther Sport*. 2011;12:2-14.
15. Azevedo DC, Melo RM, Correa RVA, et al. Uninvolved versus target muscle contraction during contract relax proprioceptive neuromuscular facilitation stretching. *Phys Ther Sport*. 2011;12(3):117-121.
16. Panteleimon B, Panagiotis I, Fotis B. Evaluation of hamstring flexibility by using two different measuring instruments. *Sport Logia*. 2010;6:28-32.
17. Russell PJ, Decoster LC, Enea D. Effects of gastrocnemius, hamstring and combined stretching programmes on knee extensibility. *Athl Train Sports Health Care*. 2010;2(2):67-73.

18. Yuktasir B, Kaya F. Investigation into the long term effects of static and PNF stretching exercises on range of motion and jump performance. *J Bodywork Movement Ther*. 2009;13:11-21.

19. Feland JB, Myrer JW, Merrill RM. Acute changes in hamstring flexibility: PNF versus static stretching in Senior athletes. *Phys Ther Sport*. 2001;2:186-193.

20. Funk DC, Swank AM, Mikla BM, et al. Impact of prior exercise on hamstring flexibility: a comparison of proprioceptive neuromuscular facilitation and static stretching. *J Strength Cond Res*. 2003;17(3):489-492.

21. Magnusson SP, Simonsen EB, Aagard P, et al. Viscoelastic response to repeated static stretching in the human hamstring muscle. *Scand J Med Sci Sports*. 1995;5:342-347

22. Bandy WD, Irion JM, Briggler M. The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Phys Ther*. 1997;77(10):1090-1096.

23. Lee JH, Yoo WG. Treatment of chronic Achilles tendon pain by Kinesio taping in an amateur badminton player. *Phys Ther Sport*. 2012;13(2):115-119.

24. Kaya E, Zinnurogiu M, Tugcu I. Kinesiotaping compared to physical therapy modalities for the treatment of shoulder impingement. *Clin Rheumatol*. 2011;30:201-207.

25. Sharman M, Cresswell A, Riek S. Proprioceptive Neuromuscular Facilitation stretching mechanisms and clinical application. *Sports Med*. 2006;36(11):929-939.

26. Chalmers G. Re-examination of the possible role of golgi tendon organ and muscle spindle reflexes in proprioceptive neuromuscular facilitation muscle stretching. *Sports Biomech*. 2004;3:159-183.

27. Hindle KB, Whitcomb TJ, Briggs WO, et al. Proprioceptive Neuromuscular Facilitation (PNF): Its mechanisms and effects on range of motion and muscular function. *J Hum Kinetics*. 2012;31:105-113.
28. Moore MA, Kukulka CG. Depression of Hoffman Reflexes following voluntary contraction and implications for proprioceptive neuromuscular facilitation therapy. *Phys Ther*. 1991;71:321-329.
29. Yoshida A, Kahanov L. The effect of kinesiotaping on lower trunk range of motions. *Res Sports Med*. 2007;15(2):103-112.
30. Ben M, Harvey LA. Regular stretch does not increase muscle extensibility: A randomised control trial. *Scand J Med Sci Sport*. 2010;20(1):136-144.
31. Vithoulk I, Beneka A, Malliou P, et al. The effects of kinesiotaping on quadriceps strength during isokinetic exercise in healthy non athlete women. *Isokinetics Exerc Sci*. 2010;18(1):1-6.
32. Babault N, Kouassi BY, Desbrosses K. Acute effects of 15 min static or contract-relax stretching modalities on plantar flexors neuromuscular properties. *J Sci Med Sport.* 2010;13(2):247-252.

LEGENDS TO FIGURES

Figure 1. The Active Knee Extension testing position.

Figure 2. The Kinesiology Tape Y-cut application.

Figure 3. The time history of changes in active knee extension with each intervention. * denotes significantly greater than baseline ($p \leq 0.05$).

Figure 4. The optimum correlational function to model the time history of changes in active knee extension for each intervention.

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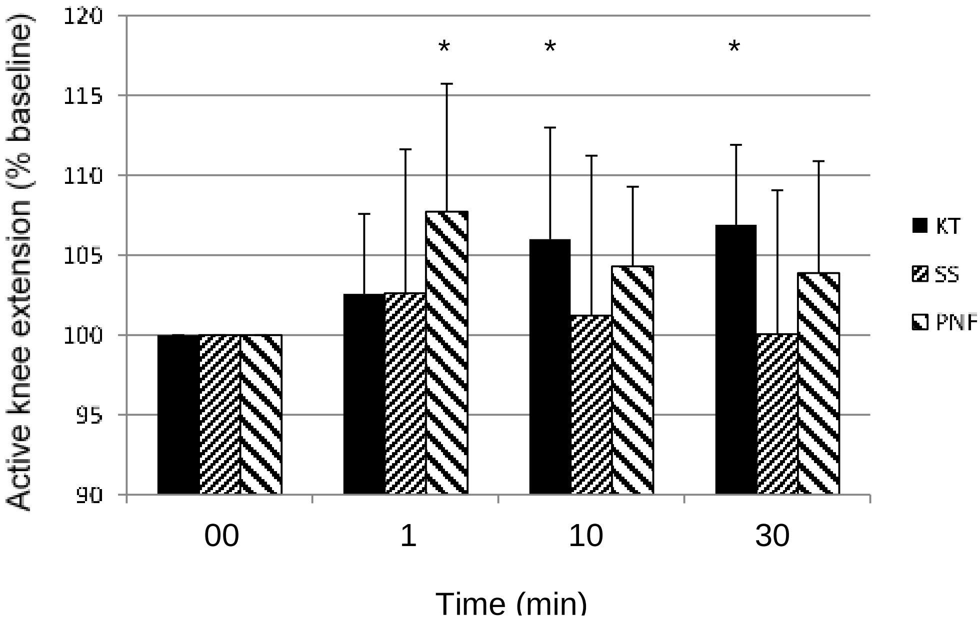

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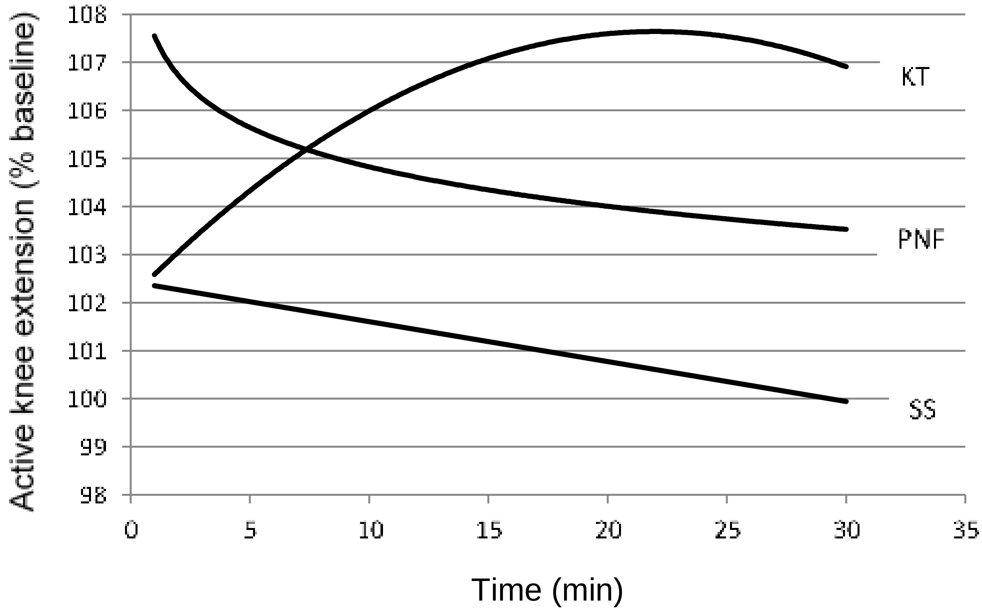

Figure 4. The optimum correlational function to model the time history of changes in active knee extension for each intervention.