RELIEF OF SPORTS FATIGUE AFTER MARATHON RACES BY PNF STRETCHING

ALÍVIO DA FADIGA ESPORTIVA APÓS CORRIDAS DE MARATONA POR ALONGAMENTO PNF

ALIVIO DE LA FATIGA DEPORTIVA TRAS CARRERAS DE MARATÓN MEDIANTE ESTIRAMIENTOS PNF

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ABSTRACT

Introduction: Marathon running requires stretching practices to relieve fatigue after exercise. The Proprioceptive Neuromuscular Facilitation (PNF) technique is an advanced stretching technique that allows segmenting of a specific muscle group for simultaneous stretching and strengthening. Objective: This paper explores the effect of PNF stretching exercise on relieving sports fatigue after marathon races. Methods: In this paper, 160 marathon runners were selected for the experiment, and randomly divided into experimental and control groups. The experimental group performed the PNF stretching exercise, while the control group remained with traditional stretching without any new intervention. Fatigue was assessed according to the heart rate, collected before, during, and after the experiment. Results: After nine weeks of PNF stretching training, the heart rate in the experimental group changed from 65.35 to 62.46 in the morning; during training, the group's heart rate changed from 180.79 to 173.04; after recovery, the first group's heart rate changed from 82.88 to 81.88. In the control group, the heart rate of the group also showed changes from 65.29 to 68.86 in the morning; during training, it changed from 180.7 to 175.49; and after recovery, from 86.23 to 88.4. Conclusion: PNF stretching exercise has a positive effect on relieving sports fatigue after marathon races. ***Level of evidence II; Therapeutic studies - investigation of treatment outcomes.***

Keywords: Proprioceptive Neuromuscular Facilitation; Muscle Fatigue; Marathon Running.

RESUMO

Introdução: A corrida de maratona requer práticas de alongamento para aliviar a fadiga após o exercício. A técnica de Facilitação Neuromuscular Proprioceptiva (PNF) é uma técnica avançada de alongamento que permite segmentar um grupo muscular específico, para alongamento e fortalecimento simultâneos. Objetivo: Este artigo tenta explorar o efeito do exercício de alongamento PNF no alívio da fadiga esportiva após corridas de maratona. Métodos: Neste artigo, 160 corredores de maratona foram selecionados para o experimento, divididos aleatoriamente em grupos experimental e controle. O grupo experimental fez o exercício de alongamento PNF, enquanto o grupo de controle permaneceu com o alongamento tradicional, sem qualquer nova intervenção. A fadiga foi avaliada segundo a frequência cardíaca, coletada antes, durante e após o experimento. Resultados: Após nove semanas de treinamento de alongamento PNF, a frequência cardíaca no grupo experimental alterou-se de 65,35 para 62,46 pela manhã; durante o treinamento, a frequência cardíaca do grupo alterou-se de 180,79 para 173,04; após a recuperação, a frequência cardíaca do primeiro grupo alterou-se de 82,88 para 81,88. No grupo de controle, a frequência cardíaca do grupo também exibiu alterações de 65,29 para 68,86 pela manhã; Durante o treinamento, mudou de 180,7 para 175,49; e após a recuperação, de 86,23 para 88,4. Conclusão: O exercício de alongamento PNF tem um efeito positivo no alívio da fadiga esportiva após corridas de maratona. ***Nível de evidência II; Estudos terapêuticos - investigação dos resultados do tratamento.***

Descritores: *Facilitação Neuromuscular Proprioceptiva; Fadiga Muscular; Corrida de Maratona.*

RESUMEN

Introducción: Las carreras de maratón requieren prácticas de estiramiento para aliviar la fatiga tras el ejercicio. La técnica de Facilitación Neuromuscular Propioceptiva (PNF) es una técnica avanzada de estiramiento que permite segmentar un grupo muscular específico, para estirar y fortalecer simultáneamente. Objetivo: Este trabajo pretende explorar el efecto del ejercicio de estiramiento PNF en el alivio de la fatiga deportiva tras carreras de maratón. Métodos: En este trabajo, se seleccionaron 160 corredores de maratón para el experimento, divididos aleatoriamente en grupos experimental y de control. El grupo experimental realizó el ejercicio de estiramiento PNF, mientras que el grupo de control permaneció con el estiramiento tradicional, sin ninguna nueva intervención. La fatiga se evaluó en función de la frecuencia cardiaca, recogida antes, durante y después del experimento. Resultados: Tras nueve semanas de entrenamiento de estiramientos PNF, la frecuencia cardiaca del grupo experimental pasó de 65,35 a 62,46 por la mañana; durante el entrenamiento, la frecuencia cardiaca del grupo pasó de 180,79 a 173,04; tras la recuperación, la frecuencia cardiaca del primer grupo pasó de 82,88 a 81,88. En el grupo de control, la frecuencia cardiaca del grupo también mostró cambios

de 65,29 a 68,86 por la mañana; durante el entrenamiento, cambió de 180,7 a 175,49; y tras la recuperación, de 86,23 a 88,4. Conclusión: El ejercicio de estiramiento PNF tiene un efecto positivo en el alivio de la fatiga deportiva después de correr un maratón. ***Nivel de evidencia II; Estudios terapéuticos - investigación de los resultados del tratamiento.***

Descriptores: *Facilitación Neuromuscular Propioceptiva; Fatiga Muscular; Carrera de Maratón.*

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INTRODUCTION

Stretching is frequently used in sports or sports training at this stage. Therefore, stretching plays an important training method in the process of preparing for sports or muscle shaping.[1] A large number of studies conducted by scholars at home and abroad have learned that PNF stretching training technology can effectively increase the flexibility of joints, effectively improve the problem of muscle fatigue, prevent musculoskeletal injury during long-distance running, and reduce the delay of muscle pain after long-distance running, so as to improve the performance of muscle swelling and pain in daily life or after long-distance running.[2] Typical PNF stretching includes three modes: dynamic stretching, static stretching and proprioceptive neuromuscular enhancement. Some studies at this stage show that although dynamic stretching exercises and static stretching exercises have brought positive effects to long-distance runners, they will have a strong negative impact on the muscles after exercise and increase the risk of injury during training.[3] Because static stretching may change the length of the stretching relationship of the tendon tissue, which may lead to the decrease of the working strength of the muscle after stretching; In the study, it was found that the dynamic stretching movement would lead to greater electromechanical delay due to the increase of muscle relaxation in tendon tissue.[4] Therefore, this would reduce the direct transmission of energy from muscle to bone force. However, it is not clear what potential adverse effects PNF stretching exercise has on muscle imbalance before exercise. Exercise fatigue is a common physical phenomenon caused by continuous overload and high-density exercise stimulation.[5] Its production mechanism mainly includes three mainstream theories of energy consumption, accumulation of metabolic products and oxidative stress. China's track and field sports are steadily improving in the overall competitive strength, but the events of men's and women's long-distance running lag far behind other sports.[6] At the same time, the long-distance running in Africa still dominates, and the long-distance running in neighboring Japan also surpasses that in China as a whole. In the context of building a "sports power" and the goal of "all-around participation" in track and field events, the 2020 Tokyo Olympic Games pointed out that it put forward requirements for improving the competitiveness of China's long-distance running.[7] Therefore, this paper discusses the extent to which PNF stretching exercises can alleviate sports fatigue after long-distance running.

METHOD

Research object

In order to ensure the scientific nature of the experiment, this paper selects 160 long-distance runners as the experimental subjects and divides them into the control group and the experimental group as a whole, and divides the groups into eight groups, so that the body data of the experimental subjects are almost consistent. The study and all the participants were reviewed and approved by Ethics Committee of Yinchuan University of Energy (NO.YCUEF207D). The age range of subjects in the experimental group is 170-177 cm, the weight range is 60-75 kg, and the average age is 20-22 years; The age range of subjects in the control group is 171-176cm, the weight range is 59-78kg, and the average age is 20-22 years old. The control group maintained the basic training method for training, while the experimental group needed to join the PNF stretching exercise while maintaining the training plan with the control group, so as to explore the effect of PNF stretching exercise on alleviating sports fatigue after long-distance running. See Table 1 for the details of the subjects.

Research methods

In this paper, the heart rate change that best represents the body state is selected as the research focus. 160 people are divided into the control group and the experimental group for comparative experiment, and 80 people in the experimental group and the control group are randomly divided, and finally 10 people in each group are tested. On the basis of keeping the long-distance runners in the original intensity of training, PNF stretching exercise was conducted on the members of the experimental group, and the heart rate changes of the long-distance runners in the experimental group during the morning, training and recovery were recorded, as well as the heart rate changes of the long-distance runners in the control group during the morning, training and recovery.

RESULTS

PNF stretching exercise relieves exercise fatigue after long distance running

Generally, the heart rate of the average person in a quiet state will be at a relatively low level. If there is aerobic or anaerobic exercise, the heart rate level will have a significant change, and with the increase of time, the heart rate will gradually increase and stabilize at a certain height. Figure 1 shows the heart rate changes of the experimental group and the control group before the experiment.

It can be seen from Figure 1 that the data of the experimental group and the control group are almost the same, because PNF stretching training has not been carried out for the experimental group. The heart rate data of the experimental group and the control group from the first group to the eighth group showed a downward trend in the morning, but the downward trend was relatively gentle, and the range of change was not large; The range of heart rate during training is 177.06-180.79, which is significantly higher than that of ordinary people during exercise; The heart rate after recovery is also higher than the range of heart rate change in the morning, which indicates that the long-distance runners are still in the state of excitement after exercise.

Table 1. List of basic information of experimental group and control group.

Experience group	1	2	3	4	5	6	7	8
Height	174.90	173.11	171.84	170.94	172.03	177.41	176.66	172.50
Weight	68.85	66.57	72.94	66.40	70.95	69.75	75.09	60.70
Age	22.04	21.02	22.83	22.79	20.46	21.60	22.16	21.63
Control group	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Height	174.05	175.02	173.06	176.64	173.54	174.48	171.67	174.66
Weight	59.07	76.38	71.91	74.95	59.04	66.63	65.15	78.37
Age	20.91	20.62	22.72	20.60	20.72	20.80	22.23	21.26

Note: Height - cm; Body weight - kg; Age - years.

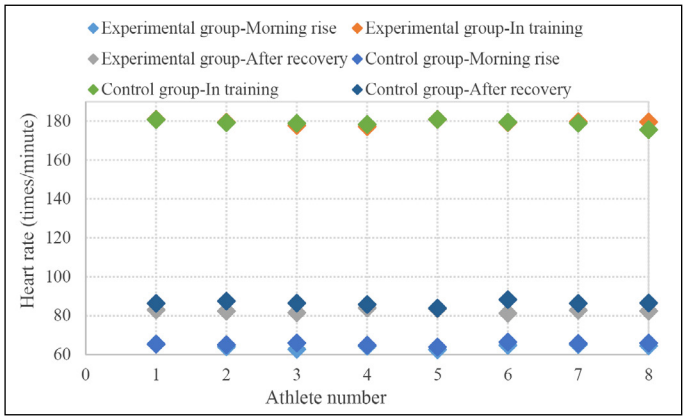

Figure 1. Changes of heart rate in the experimental group and the control group before the experiment.

After three weeks of PNF stretching exercise, the heart rate changes of the members of the experimental group and the control group were slightly different. In the experimental group, the heart rate of the first group at the morning was 62.17, the heart rate during training was 177.69, and the heart rate after recovery was 83.53; The heart rate of the members of the fifth group was 64.86 when they got up in the morning, 177.99 during training, and 82.67 after recovery; The heart rate of the eighth group was 65.19 when they got up in the morning, 175.51 during training, and 80.38 after recovery. In the control group, the heart rate of the first group was 67.05 when they got up in the morning, 178.64 during training, and 90.38 after recovery; The heart rate of the fifth group members was 68.32 when they got up in the morning, 175.74 during training, and 85.55 after recovery; The heart rate of the eighth group was 68.32 when they got up in the morning, 177.07 during training, and 88.96 after recovery.

As can be seen from Figure 2, in the morning rising stage, the heart rate of the members of the second to fourth groups of the experimental group showed a downward trend, and the heart rate of the members of the eighth group was the maximum, with a value of 65.19; The heart rate of the members of the control group is generally higher than that of the members of the experimental group. The largest difference in heart rate between the members of the control group and the members of the experimental group is in the first group, with a difference of 4.88. At the training stage, the heart rate of the experimental group members is still at a relatively high position, but there is a downward trend compared with the previous one. The heart rate ratio of the control group and the experimental group at this stage is close, and the difference is not very large. In the recovery stage, the maximum and minimum heart rate of the experimental group were 84.01 and 80.02 respectively. The heart rate change of the control group was much higher than that of the experimental group at this stage.

PNF stretching exercise changes heart rate after long distance running

It can be seen from Figure 3 that in the experimental group, after six weeks of PNF stretching exercise, long-distance runners have achieved initial results.

After six weeks of PNF stretching training, the heart rate of long-distance runners has been significantly improved in the recovery stage. Long-distance running tests the heart and lung function of the human body, and the heart and lung function is related to the heart rate. Therefore, after a certain degree of stretching, the heart rate of long-distance runners can be improved, and then the heart and lung function of long-distance runners can be adjusted to improve the performance of long-distance running. It can be seen from Figure 3 that in the morning rising stage, that is, the calm stage, the heart rate of the long-distance runners in the experimental group basically maintained below 70, and in the first group to the eighth group, the heart rate of the sixth group was the highest, which could reach 66.21, while the lowest was the third group, which was 61.29, and there was a downward trend from the first group to the fourth group; At the training stage, the heart rate changes between the experimental group and the training group are not very large. It can be seen that the heart rate of the members of the experimental group and the control group is still at a high position due to the impact of exercise intensity, and the maximum heart rate in the experimental group is 181.92, while the maximum heart rate in the control group is 180.88, with a small difference.

Figure 4 shows that after nine weeks of PNF stretching exercise, the recovery state of long-distance runners in the experimental group has greatly improved.

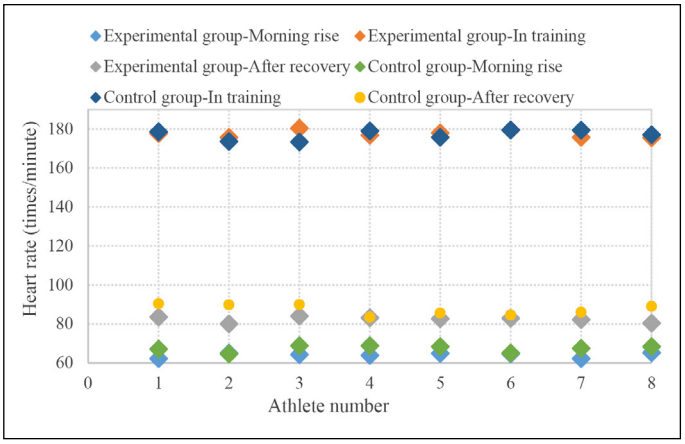

Figure 2. Changes of heart rate in the experimental group and the control group in the third week.

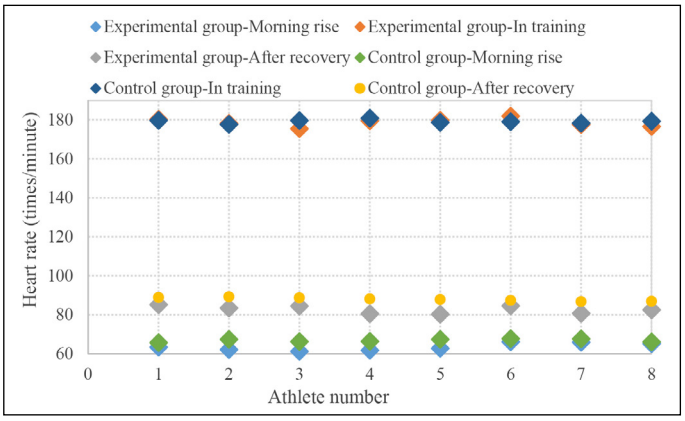

Figure 3. Heart rate changes in the experimental group and the control group in the sixth week.

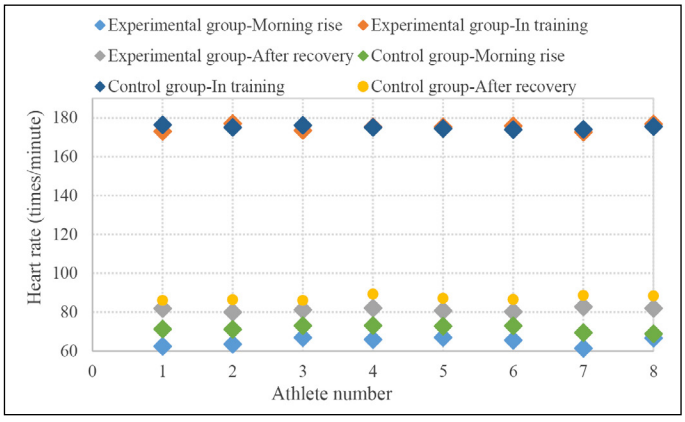

Figure 4. Heart rate changes in the experimental group and the control group in the ninth week.

For high-intensity anaerobic exercise such as long-distance running, it is necessary for the sportsman to maintain a high heart rate range for a long time during the exercise, and after the exercise, it is necessary for the sportsman to jog or walk fast to recover from the state, and add PNF stretching training after the above exercise, which can effectively help the sportsman recover from the state and increase the subsequent performance. It can be seen from Figure 4 that in the morning rising stage, the maximum heart rate in the experimental group is 66.99 in the fifth group, while the maximum heart rate in the control group is 73.11, which is quite different; During training, the range of heart rate in the experimental group was 172.65-177.06, while that in the control group was 173.98-176.42; At the recovery stage, the difference between the maximum heart rate of the experimental group and the control group was 9.26.

DISCUSSION

PNF stretching exercise, also known as proprioception nerve enhancement traction exercise, is based on the principle of using the body's proprioception system and blocking reflex nerves to promote muscle contraction. The stimulation of stretching muscle group during PNF stretching exercise will trigger the mechanism of autoinhibition. By stimulating Golgi tendon organs, the muscle tension will continue to decrease, thus reducing the resistance of stretching, which plays a very important role in improving the range of motion of joints. In addition, during the maximum isometric contraction of the muscle group by the stretching exercise target, the tension will cause the resistance to the change of the same muscle length to decrease. In addition, the reactivity of centripetal contraction antagonists causes mutual inhibition, which leads to the active reduction of target muscle resistance. In addition, PNF stretching exercise technology is usually used in clinical performance and sports environment to improve the active and passive range of motion and joint sensitivity, so as to improve the performance and rehabilitation ability of the human body after exercise. The research results show that if the target increases the range of motion, PNF technology may be an effective stretching technology at least in the short term. In addition, according to the report, this PNF technology can help improve athletes' muscle tightness and joint sensitivity after exercise, which greatly helps the ability of neuromuscular control balance and coordination (overall functional ability). PNF is the abbreviation of proprioceptive neuromuscular promotion. This is not actually a stretch type, but a technology that combines passive stretch and isometric stretch to achieve maximum static flexibility. The most common PNF technology includes two types: one is the contraction-relaxation and contraction-antagonist-relaxation of PNF. The contraction-relaxation method is to increase the length of the target muscle and keep it in this position. When the participants contract to the maximum distance of TM equidistance and keep it for a certain time, the relaxation time of TM is shorter, usually including the passive extension time. The second is that the contraction-antagonist-relaxation method follows the same steps as the CR method, and the muscles continue to work on this basis. Athletes not only passively stretch the target muscle, but also keep the isometric contraction of the opponent's muscle within a shortened range.

CONCLUSION

Long-distance running is a sport that tests physical fitness, and the people who need to run can maintain a stable heart rate. According to the experimental results in this paper, it can be seen that PNF stretching exercise can help the recovery of heart rate during long-distance running, and the effect is obvious, but the effect can only be seen after at least three weeks of persistence by long-distance runners, and in the process of morning rise, training and recovery after training, Can make the heart rate drop. Maintaining a high heart rate for a long time may have a certain impact on the safety of long-distance runners. In order to enable long-distance runners to maintain their own safety and avoid being in a high heart rate state for a long time, PNF stretching exercise can effectively reduce the maximum heart rate peak of long-distance runners, so that long-distance runners can carry out safe exercise.

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AUTHORS' CONTRIBUTIONS: The author has completed the writing of the article or the critical review of its knowledge content. This paper can be used as the final draft of the manuscript. Every author has made an important contribution to this manuscript. Xiaofeng Zhang and Zhewei Liu: writing and execution.

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