Sport and Fitness Journal
E-ISSN: 2654-9182 Volume 11, No.3, Sept 2023: 230-235

HIGH INTENSITY INTERVAL TRAINING (HIIT) CORRELATES WITH TELOMERE LENGTH

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ABSTRACT

There are many types of training for exercise in this current era where personalized workout is very popular nowadays. One of the popular workout regimens is the high intensity interval training where it only took half a time than a normal workout time, which may encourage people to exercise more. Recent studies had shown that exercise influence biological aging process, one of the markers is telomere length. One of the characteristics of cellular aging is telomere shortening, where the telomeres shorten as people age. There are many factors that may hasten or slow down this process, which is oxidative stress, lifestyle, chronic inflammation, stress, chronic diseases, and exercises. The primary goal of this literature review is to analyze and investigate the correlation between high intensity interval training (HIIT) and telomere length. The approach taken for this review is from multiple journals using many searches engine like Google Scholar, PubMed, Science Direct and Mendeley Search. The results for each article were reviewed and compared to determine the correlation between high intensity interval training with telomere length. The conclusion of this study showed that people who exercise with high intensity interval training have a considerable lengthening of telomeres.

Keywords: HIIT; high intensity interval training; exercise; telomere length; cellular aging

INTRODUCTION

Sarcopenia is a condition characterized by age-related loss of skeletal muscle mass, strength, and function. It is a common consequence of aging and can lead to decreased mobility, increased frailty, and a higher risk of falls and fractures[1]. Resistance training also known as strength training has been widely recognized as an effective intervention for preventing and managing sarcopenia. The scientific basis behind the importance of resistance training lies in its ability to stimulate muscle growth and improve muscle strength. When muscles are subjected to resistance exercises, such as lifting weights or using resistance bands, they experience mechanical tension and stress. This stress triggers a cascade of physiological responses in the body, leading to muscle protein synthesis and an increase in muscle mass and strength over time[2].

Numerous studies have investigated the effects of resistance training on sarcopenia. A systematic review and meta-analysis published in the journal Aging and Disease 2020 analyzed the effects of exercise programs for muscle mass, muscle strength and physical performance in older adults with sarcopenia. The review included data from 22 studies and reported Exercise programs showed overall significant positive effects on muscle strength and physical performance but not on muscle mass in sarcopenic older adults[3]. A meta-analysis published in the journal Sports Medicine in 2020 a randomized controlled studies that explored the effects of resistance training in very elderly on muscle strength, handgrip strength, whole-muscle hypertrophy, and/or muscle fiber hypertrophy were included in the review. The meta-analysis found a significant effect of resistance training on muscle strength in the very elderly[4].

Many traditional workouts need an hour or more of time commitment, which discourages many individuals from working out. High intensity interval training (HIIT) eliminates this restriction by reducing the time needed for a productive workout in half. HIIT is a high intensity of exercises with intervals and the duration is about half an hour. HIIT goal is to reach a significant increase of heart rate (80-90% of maximum heart rate). A survey from 2014-2022 by the American College of Sports and Medicine found that HIIT was among the top 10 fitness regimens. The aforementioned physical activity typically comprises of arduous exertion promptly succeeded by a brief pause in activity. Despite the wide variety of movements that exist within High-Intensity Interval Training (HIIT) programs, the critical element lies in the execution of high-intensity movements, which are subsequently interspersed with phases of rest and recovery[5].

Eukaryotic chromosomes have telomeres, a DNA-specific structure made up of consecutive repeats of DNA strands. By keeping chromosomal ends from fusing together, telomeres are essential for chromosomal stability and maintenance. Enzyme telomerase maintains the telomere integrity. In humans, shortening of the length of telomeres indicates an aging process. The consequential constraints of DNA polymerase in replicating the 3' termini of telomeres instigate an attrition of 30 to 150 base pairs during each cellular division. Telomere length and chronological age are closely related, and the former is even used as a measure of biological age or cellular aging. When the length of telomeres surpasses certain predetermined thresholds, cellular proliferation decelerates, the functionality of the cell may depreciate, and the possibility of cellular demise is likely to transpire. The telomere length is not the sole factor that influences chromosomal instability, cell aging, or apoptosis; disruption of related proteins also may cause this problem[6].

People with active physical training have longer telomeres than people with a sedentary lifestyle, which shows there is a noteworthy correlation between physical activity and telomere length. The latest research investigates the correlation between physical activity and the reduction in telomere length shows that regular exercise increases antioxidant activity and promotes REDOX equilibrium, which may attenuate telomere shortening [7,8,9,10].

Several investigations are still being conducted as the classification of the impact of different exercise protocols on telomere length remains elusive. This literature review aims to explore various research findings about the relationship between high intensity interval training (HIIT) and telomere length.

METHODS

The approaches taken for this literature review are the internet journal and article searches using Google Scholar., PubMed, Science Direct, and Scopus with keyword “high-intensity interval training” and “telomere length”. The inclusion criteria are journal between 2013 to 2023.

RESULTS

We included 3 studies that have been analyzed in the table below.

Table 1. The high intensity interval training correlates with the telomere length

No.	Author and Publications	Design	Sample	Intervention given	Length of study	Results
1	Werner et al, 2019	Cohort study	124 men and women Age 30-60	AET, HIIT and RT 3 session per week	6 months	Through endurance training and high-intensity IT, telomerase activity and telomere length are significantly increased. But resistance training

						has no effect on the activity of telomerase or the length of the telomeres.
2	Mofrad et al, 2018	Quasi-experimental pre-post intervention study	30 men	HIIT exercise 3 session a week with an intensity of 150 – 175% maximum power.	8 weeks	Telomere length and telomerase activity both significantly increased (p0.001).
3	Mosallanezhad et al, 2019	quasi-experimental pre-post intervention study	21 women Age 20 – 26	HIIT exercise 3 session a week	8 weeks	Leucocyte telomere length (p=0.04) and telomerase activity (p=0.04) have both significantly increased.

DISCUSSION

a. Telomere Length

The ratio of lengthening to shortening, which dictates the average length and length distribution of telomeres, is influenced by various factors, encompassing genetic, physiological, and developmental aspects. that contribute to telomere maintenance in eukaryotic cells. The maintenance of telomeres, which are structures located at the ends of chromosomes in eukaryotic cells, is dependent on several factors. Two significant factors include the telomerase activity and the components of the telomere itself. These factors are essential to prevent the progressive shortening of telomeres during cell division, and to ensure chromosomal stability and overall cellular health[11].

At the ends of chromosomes the are telomeres sequence of repeated DNA (5′-TTAGGGn-3′) that work with telomere-binding proteins to prevent DNA ends from being damaged[12]. In order to maintain the stability of the genome and the chromatin structures necessary for transcription, telomere length is necessary[13]. Telomere length is arranged by two opposite mechanisms, which are attrition and elongation. Enzyme telomerase regulate elongation of telomere partially, so telomere could possible reverse rejuvenates cells and maintaining cellular aging. This can maintain and/or lengthen telomeres in some tissues, which can prevent telomere shortening [14]. Telomere has role as bioprotective of chromosome attrition at cells. Aging process can make telomere DNA damaged, inadequate mitotic tissue replication, unrepaired telomere DNA damaged, and telomere end processing all contribute to telomere shortening over time[15].

It is widely believed that the length of telomeres remains stable throughout childhood and into adulthood but experiences a gradual decline during the later stages of adulthood. Inter-individual differences are notable regarding telomere length and its rate of attrition throughout the lifespan. Due to the observed inverse correlation between age and telomere length, it has been postulated that telomere length may serve as a plausible cellular biomarker for biological aging[16]. Moreover, leukocyte telomere length appears to be a biomarker for healthy aging because it is positively correlated with the many years lived in good health[17].

b. High Intensity Interval Training (HIIT) Association with Cellular Aging (Telomere Length)

Physical exercise and persistent endurance training are linked to a reduction in morbidity and mortality as well as a delay in cellular aging[18.] When compared to counterparts who are sedentary, people who consistently engage in moderate to high levels of physical exercise had longer telomere length in various tissues[19].

Many journals showed physical exercises can reduce oxidative stress (cell damaged) due to production of ROS. Oxidative stress can lead aging process by chromosomes damaged and shortening telomere length. In many articles found one of the effective exercises is HIIT. High-intensity interval training has been found to have potential for reducing body fat and enhancing the strength and endurance of skeletal muscles. HIIT has role in reduction and prevention of disease symptoms, moreover telomere length. The proper types of aerobic exercise can decrease the risk of cardiovascular and metabolic disorders. However, this can be time consuming. Additionally, some restrictions are posed by the nature of particular workouts, such as endurance exercises, which require for constant effort. It would appear important in this regard to investigate an alternative training regimen that would provide comparable metabolic adaptations without the time commitment concern. High-intensity interval training (HIIT) is one of the workout regimens that exercise physiology researchers have recently investigated. HIIT consists of periods of vigorous exercise and periods of low-intensity activity throughout the recovery period. In HIIT, the intervals of low-intensity exercise between repeated exercise intervals mean that more exercises are performed with higher rates of effectiveness[5,6].

There are three studies evaluated how telomere length is influenced by high-intensity interval training. According to one study using a randomized controlled trial, endurance training, interval training, and resistance training treatments cause circulating leucocytes to activate particular biological pathways. Telomere length and telomerase activity, which are vital to cellular senescence, regenerative ability, and consequently healthy aging, were improved by endurance training and interval training and not resistance training[20].

Another study revealed that 30 inactive students were randomly assigned to two groups for the semi-experimental study's eight weeks of HIIT training in non-athlete young men. The exercise group consisted of 15 participants, while the control group included 15 participants. With an intensity ranging from 150 to 175% of their maximal power (Pmax), the workout group practiced HIIT for 8 weeks in 3 sessions each week. The subjects in the control group did not regularly practice sports. Telomere length and telomerase activity were assessed using 10 milliliters of blood retrieved from the brachial veins of patients prior to and post completion of their final exercise session, with a time lag of 24 hours for each collection. The statistical tool known as the dependent t-test was employed to examine intra-group variations, while the independent t-test was utilized to evaluate differences within groups. The results of this study found a significant increase in telomere length ($P = 0.001$) and telomerase activity ($P = 0.001$). So, HIIT appears to have the ability to change telomerase activity and telomere length. As a result, this training might benefit cell biology[6].

The purpose of the third study was to examine the effect of eight-week high-intensity interval training (HIIT) on telomere length and telomere factors of leukocytes in sedentary young women. This study demonstrated a significant increase in telomerase activity ($p=.04$) and leukocyte telomere length (T/S ratio) ($p=.04$) in the experimental group. In addition, the experimental group's weight, BMI, and body fat percentage all dramatically dropped. The experimental group engaged in three HIIT workouts each week for eight weeks. Every session featured three to six runs at top speed over a 20-meter distance with a 30-second break in between. Blood samples from fasting subjects were taken both before and after the exercise protocol. Real Time PCR was used to measure the telomere length. Both independent and paired t-tests were used to assess the data[16].

The limitations in this study due to a lack of research about correlation of high intensity training and sarcopenia in elderly, so in this study there is a lack of comparisons for each research. High intensity training can be an alternative to improve strength of skeletal and muscle mass in sarcopenic patient (elderly patient). It is hoped that future sport research will be conducted with a larger sample size, gender balance, and specific age restriction criteria.

CONCLUSION

Recent studies had shown that high intensity interval training significantly influence biological aging

process, one of the markers is telomere length and telomere activity. One of the characteristics of cellular aging is telomere shortening. The results of our literature review show that high intensity interval training has the effect of lengthening the telomere. But this factor can be influenced by age, sex and different population. More investigation is required to determine what type, intensity and duration of the exercise that can improve the cellular aging, including the shortening of telomeres.

CONFLICT OF INTEREST

No conflicts of interest are disclosed by the authors.

ACKNOWLEDGEMENT

All of the authors would like to express their gratitude to the Head and all members of the Physiology Department Medical Faculty at Udayana University Denpasar, Indonesia, for their assistance and the opportunity to contribute to this literature study.

REFERENCES

1. Santilli V, Bernetti A, Mangone M, Paoloni M. Clinical definition of sarcopenia. Clin Cases Miner Bone Metab. 2014;11(3):177–80.
2. Law TD, Clark LA, Clark BC. HHS Public Access. Physiol Behav. 2019;176(3):139–48.
3. Bao W, Sun Y, Zhang T, Zou L, Wu X, Wang D, et al. Exercise programs for muscle mass, muscle strength and physical performance in older adults with sarcopenia: A systematic review and meta-analysis. Aging Dis. 2020;11(4):863–73.
4. Grgic J, Garofolini A, Orazem J, Sabol F, Schoenfeld BJ, Pedisic Z. Effects of Resistance Training on Muscle Size and Strength in Very Elderly Adults: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Vol. 50, Sports Medicine. 2020. p. 1983–99.
5. Thompson WR. Worldwide Survey of Fitness Trends for 2021. ACSM's Heal Fit J. 2021;25(1):10–9.
6. Mofrad. 1. Department of Physical Education and Sports Sciences, Shahid Beheshti University, Tehran, Iran *. 2018;5(2):1–7.
7. Investigation O. The Association Between Physical Activity in Leisure Time and Leukocyte Telomere Length. 2008;168(2):154–8.
8. Sellami M, Bragazzi N, Prince MS, Denham J, Elrayess M. Regular, Intense Exercise Training as a Healthy Aging Lifestyle Strategy: Preventing DNA Damage, Telomere Shortening and Adverse DNA Methylation Changes Over a Lifetime. Frontiers in Genetics. 2021.
9. Lin X, Zhou J, Dong B. Effect of different levels of exercise on telomere length: A systematic review and meta-analysis. Journal of Rehabilitation Medicine. 2019.
10. Song S, Lee E, Kim H. Does Exercise Affect Telomere Length? A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Medicina (Lithuania). 2022.
11. Blackburn EH. Switching and Signaling at the Telomere. 2001;106:661–73.
12. De Lange T. Shelterin: The protein complex that shapes and safeguards human telomeres. Genes Dev. 2005;19(18):2100–10.
13. Oh H, Taffet GE, Youker KA, Entman ML, Overbeek PA, Michael LH, et al. Telomerase reverse transcriptase promotes cardiac muscle cell proliferation, hypertrophy, and survival. Proc Natl Acad Sci U S A. 2001;98(18):10308–13.
14. Shay JW, Wright WE. Senescence and immortalization: Role of telomeres and telomerase. Carcinogenesis. 2005;26(5):867–74.
15. Greider CW, Blackburn EH. Tracking telomerase. Cell. 2004;116(2 Suppl):83–7.
16. Muezzinler A, Zaineddin AK BH. A systematic review of leukocyte telomere length and age in adults. Ageing Res. 2013;12:509–19.
17. Njajou OT, Hsueh WC, Blackburn EH, Newman AB, Wu SH, Li R, Simonsick EM, Harris TM, Cummings SR CR. Association between telomere length, specific causes of death, and years of healthy life in health, aging, and body composition, a population-based cohort study. J Gerontol A Biol Sci Med Sci. 2009;64:860–4.
18. Blair SN, Kohl HW, 3rd, Paffenbarger RS, Jr, Clark DG, Cooper KH GL. Physical fitness and all-cause

mortality. A prospective study of healthy men and women. JAMA. 1989;262:2395–2401.
19. Cherkas LF, Aviv A, Valdes AM et al. The effects of social status on biological aging as measured by white-blood-cell telomere length. Aging Cell. 2006;5:361–365.
20. Werner CM, Hecksteden A, Morsch A, Zundler J, Wegmann M, Kratzsch J, et al. Differential effects of endurance, interval, and resistance training on telomerase activity and telomere length in a randomized, controlled study. Eur Heart J. 2019;40(1):34–46.