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Original Article

A Study on the Application of Music to Improve the Exercise of a Running Machine

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Abstract *- In general, running exercise is an outdoor exercise that requires running a long distance, so there are many restrictions depending on the terrain, season, and weather conditions. In order to compensate for such shortcomings, a running machine, which is an exercise device that can continuously run in a fixed place indoors, is being used. However, because the running machine has to run for a long time in one place indoors, it is often stuffy and boring, so it is easy to give up running exercise. To compensate for such shortcomings, you can exercise on the running machine while listening to music, but if you do the running machine exercise while listening to music that does not match your running speed, the exercise effect may decrease. Instead, if you exercise while listening to music that matches the running speed of the running machine, you will be able to run more effectively. In this paper, to relieve boredom and pain when exercising on a running machine, a study was conducted in which the running machine provides music with an appropriate number of beats according to the speed selected by the exerciser. As a research method, several speeds were selected on the running machine prepared for the experiment, and the sound of footsteps was recorded while walking or running. Second, a metronome extracted the number of beats corresponding to the speed from the recorded footstep samples. Finally, I tried to find and match the genre of music suitable for the number of beats extracted from the sound of footsteps. When running indoors on a running machine, if the appropriate genre of music flows naturally from the running machine according to the running speed you choose, you can enjoy the best exercise effects.*

Keywords *- Running machine, Running exercise, Beat number, Exercise effect, Music genre, Metronome.*

1. Introduction

The Research results have already been studied for a long time that the efficiency increases when working while listening to music or singing while performing simple or repetitive tasks. As much as that, music excites people, so they can overcome pain under challenging situations and relieve stress. In particular, many people give up running exercise because it is repetitive and boring and causes pain similar to when doing physical work. However, when performing physical labor or repetitive exercise, if you play the music that matches the speed of the movement, a rhythm is generated as if dancing according to the music, which offsets the boredom and pain of labor or exercise. Among sports, running using a running machine is physically difficult because it requires continuous running in a fixed place indoors. This paper is based on a method to make the running machine provide appropriate music according to the speed through its own AI algorithm. Since the running machine can select various speeds and set various exercise programs, naturally providing music suitable for the speed selected by the person who wants to exercise will relieve boredom and pain. For this study, the speeds 4, 6, 8, 10, and 12 m/h are basically set, and a running machine that can select each speed was prepared. This study aims to achieve the best effect in running exercise by naturally and automatically applying music suitable for each step according to each speed that can be selected on the running machine. As a research method, first, the speed of each of the five steps that can be selected from the prepared running machine is set one step at a time, and then the running exercise is performed, and footstep sounds are recorded at each step. Next, the number of musical beats is derived by analyzing the running step sounds of five recorded patterns using a metronome. Finally, we find the music genre associated with the number of beats derived from the running footsteps of each of the five patterns. In fact, to commercialize a running machine that automatically selects and plays music according to the speed, the copyright of music must be considered, so it is revealed that in this paper, music was studied as an example, only focusing on genres.[1]

2. Running Machine for Experiment

The beginning of running machine was used as a punishment tool for prisoners in England in the 19th century. Its initial form was a cylinder with a footrest attached to it, and it is said that it was a torture tool to inflict "simple repetition pain" on prisoners. In prisons, early running machines used the rotational force of a cylinder that prisoners stepped on to dissolve water or grind grain. In the UK, it is said that over 50

prisons for 10 years used this punishment tool before it was stopped because it violated human rights. Therefore, it is sometimes used as the name treadmill, a compound word for tread and mill. However, in the original foreign language notation, the running machine is the standard language, and the running machine is commonly used in both spoken and written language.

a) Running machines at the gym

b) Running machine instrument panel

Fig. 1 Running machine

For reference, in American English, the name treadmill is used more than running machine. However, in this paper, the expression "Running machine" is used in England, the hometown of English and the place where the penal tool originated; the treadmill was first made in England so we will express it as a running machine. The principle of the running machine is that a wide band wound around a cylinder rotates continuously, allowing you to run repeatedly in place for a long time, just like running outdoors. The running machine is also the most installed exercise equipment, along with a cycle for aerobic exercise and diet in the fitness club. As shown in Figure 1, the running machine prepared for this study was tested by preparing a running machine manufactured by "Any Fitness" in Korea in 2015. "Any Fitness" running machine is a running machine with 5 speeds and 5 programs to choose from. The "Any Fitness" running machine has 5 buttons set to 4, 6, 8, 10, and 12m/h so that you can change the speed easily. "Any Fitness" running machine can be fine-tuned to speeds below 4 m/h, as well as speeds of 5, 7, 9, 11 m/h and in-between. This study was conducted using 5-speed buttons, 4, 6, 8, 10, and 12m/h, which are set so that the "Any Fitness" running machine can be easily selected. The "Any Fitness" running machine is also equipped with a patch that allows it to stop immediately in an emergency.[2]

2.1. The Exercise Effect of Running the Machine

The running machine was born as a punishment tool devised to manage inmates in a British prison, but Louis Attila of Germany started it as an exercise device used by ordinary people. Luis Attila knew running machines effectively developed lower body muscles and actively promoted them. In the 1950s, it was also used for medical purposes to measure cardiorespiratory capacity, and it gradually spread to fitness clubs and became famous. The running machine used as an early exercise device was a passive device that held the handles on both sides and forcibly rotated the rubber plate on the roller using friction with the bottom of the running shoe. After that, it was developed into an electric running machine that automatically rotates the roller using a motor with electric power and runs while running according to the speed of the roller on it. On the other hand, people on the running machine, which rotates a wide rubber plate with the power of an electric motor to repeatedly run in place, seemed to have turned into squirrels, and some people gave negative opinions. In the early days of electric running machines, only the speed was selectively selectable, and the speed was displayed on the instrument panel. After that, the manufacturing technology of the running machine was developed gradually, and the instrument panel of the running machine was made into a digital liquid crystal screen so that the loaded program and the speed of each step could be selected, and the progress was also shown. The current running machine sets the preferred speed step by step and sets several programs to give various speed changes within the program to enhance the running exercise effect. It also checks and informs you about the progress and speed of the program, calorie consumption, blood pressure and pulse rate. Furthermore, recently, by linking personal wearable devices such as mobile phone watches and running machines, it shows the amount of exercise and the degree of goal achievement based on accurate data and manages an individual's exercise plan.[3]

2.2. Comparison of the Running Machine and Outdoor Running Exercises

A study on exercise physiology was conducted on the difference between the exercise effect of running machines and outdoor running. As a result, if air resistance is excluded, the effect of running machine exercise and outdoor running exercise is almost the same. However, kinematically, the running machine and outdoor running have the same direction

of relative motion between the body and the ground. Since you have to walk a long distance by stepping on a fixed surface yourself, an outdoor running exercise inevitably consumes more calories or energy than an indoor running machine exercise. In addition, outdoor running exercise has more significant variables depending on the season, weather, and surface. However, it is said that some marathon runners use running machines for long-distance running or marathon training because outdoor running and indoor running machine exercise have little difference in exercise effect at low speeds. Running machines that can be used indoors can perform running exercises at any time, regardless of the season or weather, but they also have the disadvantage of having to do tedious running exercises in a fixed place while looking at a stable environment. Of course, outdoor running also has its pros and cons. Table 1 compares the advantages and disadvantages of running exercises with the running machine and outdoor running exercises.[16]

2.2.1. Advantages and disadvantages of The running machine' running exercise

We summarized the pros and cons of running machine exercises. First of all, the advantage of running machine exercise is that you can do running exercise at any time 365 days a year, regardless of the season, weather, cleanliness of the air, and the good or bad of the ground. The disadvantage is that most of the running machines are fixed in one place indoors, so even in a spacious fitness center, the stuffiness and boredom from the closedness of the room adversely affect the activeness and continuity of the exercise. Because of this point, some people feel that running machine exercise is more complex than outdoor running exercise. In addition, various accidents due to running machines occur. Accidents occur most frequently in falling due to inadvertently changing the speed rapidly and failing to run according to the speed, and burn accidents due to pinching or friction also occur. In particular, as accidents for infants and children due to running machines frequently occur, be sure to unplug the power plug when not in use to prevent accidents.

2.2.2. Advantages and Disadvantages of Outdoor Running Exercise

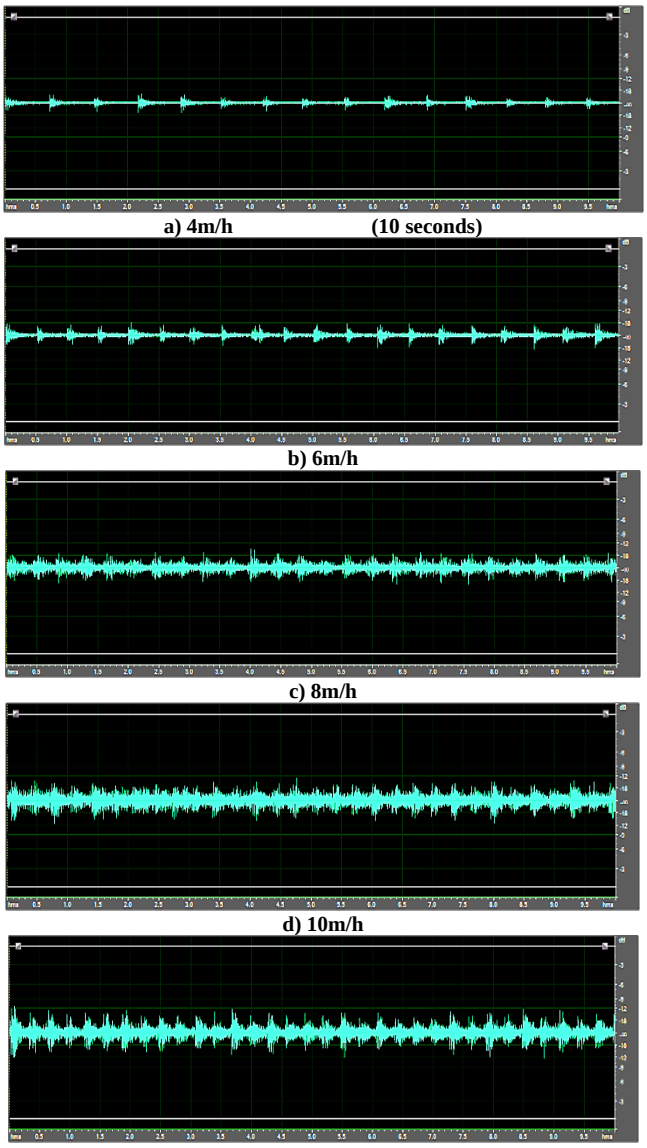
It has summarized the pros and cons of outdoor running exercises. First, it can be suggested that the advantage of outdoor running exercise is that you can enjoy running while breathing in the pleasant air in a spacious and open outdoor environment while admiring the beautiful scenery that approaches and passes. Of course, if the weather is good in spring or autumn, if you do a running exercise on a well-maintained road in a rural village with good air. Fortunately, running courses have recently been well established in the mountains or forests near parks or residential areas, so outdoor running is the best exercise if you choose the season or the weather well.

3. Effective Ways to Apply Music for Running Machine Running Exercise

Music is an art born in the realm of sound. Music is a sound art created by humankind that consists of three elements: rhythm, melody, and harmony in the characteristics of sound. Music controls human emotions, connects them to affect the human body, excites them, and makes them dance. From time immemorial, music has been used in festivals for solidarity ceremonies. It was also used to increase work efficiency in the workplace.

Table 1. Comparison table of advantages and disadvantages of the running machine and outdoor running exercise

Contextual / Division	Running machine	Outdoor running exercise
Advantages	- It can exercise consistently regardless of the air condition, season, or weather. - There is honesty in the running effect because the speed and the floor are constant. - It is possible to reduce the risk of accidents that may occur due to the external environment.	- Running in the fresh air is good and suitable for your health. - Because you run while stepping on the ground directly, the exercise effect on your legs is greater. - The changing environment makes the exercise not boring.
Disadvantages	- Because it is electrically operated, the exercise efficiency may decrease. - Because it is an indoor space, you may feel bored. - Poor ventilation can harm your health.	- Yellow dust, fine dust, and smoke can actually harm your health. - Outdoor jogging is not possible depending on the season and weather. - Dangerous accidents may occur due to the road surface or the surrounding environment.
Precautions	- Because it is an automatic exercise device, it may be exposed to safety accidents such as falling, pinching, and friction. - In particular, caution is required for children and the elderly.	- Must predict the season and weather conditions well, wear sportswear and sneakers, and run while observing the terrain and conditions.



a) 4m/h (10 seconds)

b) 6m/h

c) 8m/h

d) 10m/h

e) 12m/h

Fig. 2 Time domain graph for analyzing walking beat by the speed of the running machine

The effectiveness of the music also applies to exercise. Aerobics, rhythmic gymnastics, and fitting are examples. In this paper, a study was conducted to improve exercise efficiency by grafting a musical rhythm suitable for the speed of a running machine. Of course, we are trying to maximize the effect of exercise by playing fast-tempo music throughout the fitness center. However, since the running machine has to select various exercise speeds according to the exerciser's situation, it is necessary to apply the music more delicately to give a more reliable exercise effect. The basic speed of the running machine to be studied is set to 4, 6, 8, 10, and 12 m/h. In addition, fine adjustments can be made in 1m/h increments from 1m/h to 20m/h. This study decided to apply music genres that can effectively exercise at speeds of 4, 6, 8, 10, and 12m/h, which are basically set on the "Any Fitness" running machine.

In the meantime, exercisers used their smartphones or MP3s to select music suitable for their speed and listened to them through speakers or Bluetooth earphones while exercising. However, this study is a method in which the running machine selects appropriate music according to the speed the exerciser selects by the built-in AI system and listens to it through a speaker or Bluetooth earphone. The running machine can learn and can automatically provide a music genre according to the taste of the exerciser. In order to select music suitable for the speed of the running machine, the number of beats suitable for the speed selected by the exerciser should be calculated with the metronome, and the appropriate music genre should be extracted. First, the sound of footsteps corresponding to the speed of the running machine was recorded, and the number of beats was calculated using the metronome.[5][6]

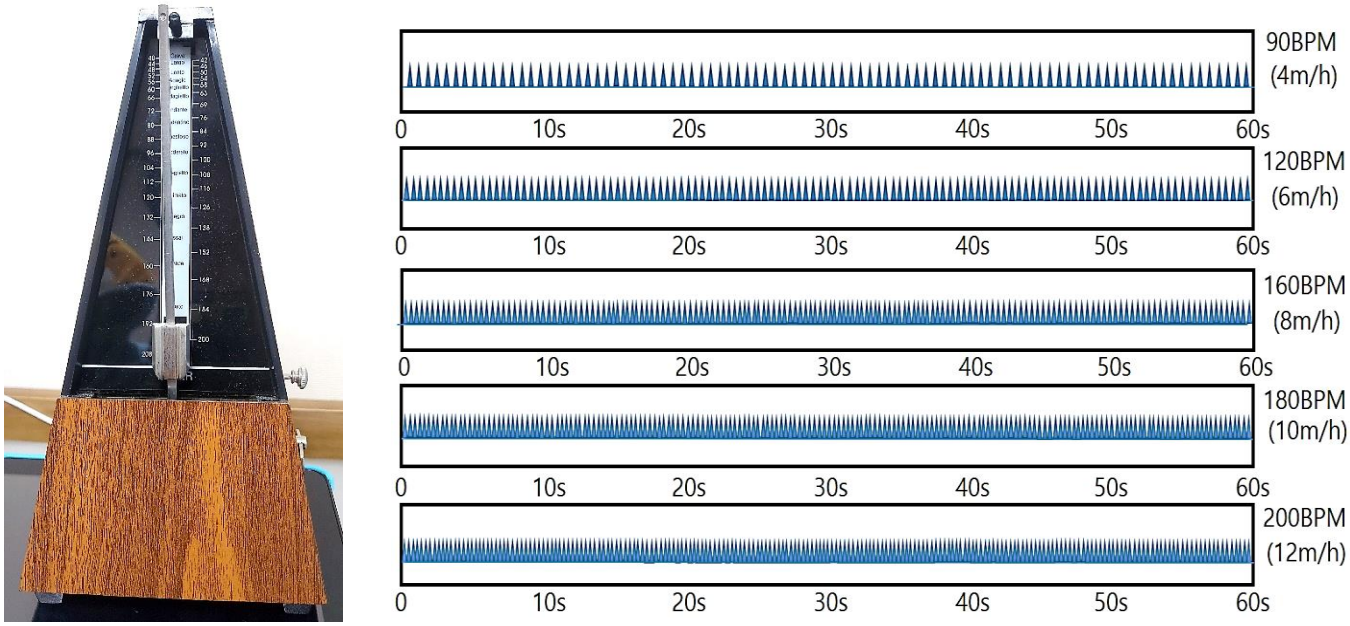
3.1. A study of Walking Tempo by the Speed of the Running Machine

In order to study the walking beat for each speed of the running machine, a running machine of "Any Fitness" produced in 2015 in Korea was prepared and tested. This paper tried to figure out the walking speed by recording footsteps based on the speed of 4, 6, 8, 10, and 12m/h set as the basic speed on the running machine. As a method to study the sound of footsteps by the speed of a running machine, it was analyzed using a time domain graph in Adobe's audition program, an acoustic analysis tool. To record the sound of footsteps for each speed of the running machine, a digital SD recorder, H2 recorder, was used. By selecting the 4, 6, 8, 10, and 12 m/h speeds that are basically set in the "Any Fitness" running machine, the beat was derived by recording footsteps at each speed.[7][8]

The time domain graph for analyzing the walking beat by running machine speed in Figure 2 is a time domain graph expressing the steps for 10 seconds at each speed as a waveform. As a result of deriving the footstep sounds for each speed of the running machine as a time domain graph, 4m/h is 15 steps in 10 seconds, 6m/h is 20 steps in 10 seconds, 8m/h is 26 steps in 10 seconds, and 10m/h is 31 steps in 10 seconds and 33 steps in 10 seconds at 12 m/h. The number of steps for each speed is calculated as the number of beats using a metronome to incorporate it into a musical beat.

3.2. Comparison of the Number of Beats by the Speed of the Running Machine using the Metronome

This study is to help people who exercise by generating music with appropriate rhythm according to the running speed of the running machine by itself to relieve boredom and frustration during running exercise using a running machine. In order to understand the beat of the running motion by the speed of the running machine, the sound of footsteps for each speed of the running machine recorded in 3.1 was confirmed as a time domain graph of Adobe's audition program. In 3.2, to graft, each suitable music genre for each running speed of



a) Metronome **b) Number of beats by running machine speed**

Fig. 3 Comparison graph of running machine walking speed and number of beats using a metronome

the running machine, the footsteps identified in the time domain graph in 3.2 was derived as the number of musical beats using a metronome. The speed of a running machine is expressed in units of m/h (MPH: Miter Per Hour), indicating distance per hour. The speed of music is expressed in units of Beats Per Minute (BPM), in which musical beats are expressed in terms of time. As a result of deriving the number of beats corresponding to 4, 6, 8, 10, and 12m/h, which are the five-step speeds of the running machine, 4m/h is 90BPM, 6m/h is 120BPM, 8m/h is 160BPM, 10m/h was found to be 180 BPM, and 12 m/h was found to be 200 BPM.[9][10]

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3.3. Music Matching Study by Speed Unit of Running Machine

According to the speed selection of the running machine, a study was conducted to set the rhythm of the music suitable for the speed. In order to apply the music according to the step speed of the running machine, it is necessary to check the tempo of the music according to the number of steps. In music, the tempo is calculated in beats per minute, and the unit is expressed in beats per minute (BPM). The tempo of music or other regular sounds can be measured using a metronome. In order to match suitable music according to the speed change of the running machine, the bpm of the number of steps per speed unit of the running machine should be calculated using the metronome. Then, you must select or compose music that corresponds to the BPM of each speed step. These days, composing is recommended due to copyright issues.

Alternatively, the right to use must be obtained in consultation with the Copyright Association and the record producer. First, to investigate the BPM by the speed of the running machine, the study was conducted based on the running machine manufactured by "Any Fitness" prepared for this study. Based on the speed levels 4, 6, 8, 10, and 12m/h, set on the running machine manufactured by "Any Fitness", each BPM was investigated, and music corresponding to that BPM was searched. A running machine speed of 4-5 m/h has a tempo of 90 BPM, and the corresponding music includes Hip-hop, Dance-pop, and Latin pop.

Among them, Hip-hop is a music genre created by black or Spanish teenagers in Harlem, New York, USA, in the late 1970s, and is classified into Boom Bap and Trap. Boom Bap is based on 80 ~ 100 BPM. Dance-pop is a music genre that started as dance-oriented pop music in the early 1980s and developed into disco music. Dance-pop music is usually made up of solid and straightforward beats. Also called Latin Pop, it consists of 65-110 BMP. The metronome tempo, which corresponds to a running machine speed of 6-7 m/h, is 120 BPM, and there are music categories such as Disco, House, Techno, Big beat, Trance, and Eurobeat. Disco-type music is the popular music of the late 1970s and has a tempo range of 110-130 BPM, and 120 BPM is the most common.

Table 2. Related Music Genres by Running Machine Speed

Running Machine Speed (Metre Per Hour)	walking speed	BPM (Beats Per Minute)	Related music genre
4 ~ 5 m/h	walking slowly	90 BPM or higher	Hip-hop (Boom-bap, Trap), Dance-pop, Latin pop
6 ~ 7 m/h	walking fast	120 BPM or higher	Disco, House, Techno, Big beat, Trance, Eurobeat
8 ~ 9 m/h	run slowly	160 BPM or higher	Death metal, Drum and bass
10 ~ 11 m/h	run normally	180 BPM or higher	Death metal, Hardcore, Techno
12 m/h ~	run fast	200 BPM or higher	Hardcore, Techno, Speedcore

House music was born in the early 1980s, when the Disco boom, which was hot at the time, withered, and to revive the boom, Chicago DJs in the United States used electronic equipment to dance in a club with a four-quarter beat and repeated Drum machine music. Music such as Techno, Big beat, Trance, and Eurobeat is also a kind of Dance music using electronic instruments from the 1980s to the 1990s. The metronome tempo, which corresponds to a running machine speed of 8 to 9 m/h, is 160 BPM, and there are music genres such as Death metal and Drum and Bass.

Death metal is a branch of metal music that was born between the mid-late 1980s and has a faster and more radical texture than thrash Metal and Heavy metal. It was born as a genre of Electronica in the UK at the same time as Metal music and showed new attempts in the 1990s, but recently it is a music genre that uses a fast Breakbeat of 160~180BPM. The metronome tempo, which corresponds to a running machine speed of 10 to 11 m/h, is 180 BPM and corresponds to music genres such as Death metal and Hardcore techno. It is a music class. The metronome tempo, which corresponds to a running machine speed of 12 m/h or higher, corresponds to Hardcore Techno and Speedcore music at a level of 200 BPM or higher, and it is a music genre that uses the insanely fast tempo that can be used with Electronic music. [11][12][13]

4. Conclusion

When Corona 19 peaked in 2021, the Korean government raised the distance from July 12 to level 4 and tightened various regulations. Among them, if you exercise on the running machine at the fitness center, as a rule related to the gym, the speed of the running machine should be 6m/h or less for fear that droplets will be dispersed due to hyperventilation was to be maintained. However, the occurrence of droplets due to hyperventilation differs from person to person, and there are many public opinions that the speed limit of music is not very helpful for quarantine, so the issue of effectiveness has been raised. Since music moves people's bodies and leaves them to rhythm and beat, hip-hop, rock, and pop music are widely used. In 1911, Leonard Ayr of the United States obtained the first results that music helps exercise effect through a study that cyclists improved their records according to music. Scientifically, music suppresses the secretion of stress hormones, helps the body move more efficiently, and maintains a stable breathing and heart rate, positively affecting blood pressure and the endocrine system. As a result, there is a study result that improves the effect of exercise by eliminating fatigue from exercise. You can enhance the exercise effect if you associate music with not only a running machine but also a stepper, an indoor bicycle machine, and an elliptical machine. In particular, a music genre with a tempo of 120 to 145 beats is known as the music that has the most effect on exercise. If AI is the basis for the running machine, it will learn the taste of the person using the running machine by itself and provide the appropriate genre of music according to the speed at which it is selected. Various exercise equipment and running machines have been established as health management tools by checking and reporting an individual's calorie consumption, blood pressure and pulse. If the AI mounted on the treadmill learns the personality and exercise habits of the person who wants to exercise and provides appropriate music for the selected speed, it will greatly affect the treadmill exercise. Nowadays, when smart environments are established, personal wearable devices such as mobile phone watches and running machines can be linked to enhance the effect of exercise by communicating music that suits individual tastes.[14][15]

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