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High-Intensity Interval Training Specific Programming: Effects on Wheelchair Tennis Players' Reactive Agility

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ABSTRACT

Background: The programming of wheelchair tennis physical exercises to improve reactive agility needs to be studied more deeply. The training method must be adjusted to the characteristics of the movement of the match technique, the energy system and the type of disability. The appropriate training method is high-intensity interval training (HIIT). However, HIIT is still common. **Objectives:** This study aims (1) to compile HIIT-specific programming, (2) to test the effectiveness of HIIT specific programming on reactive agility. **Method:** This is a research development with a 4D approach. The sample was 20 wheelchair tennis athletes, male and female, aged 28-36 years, weighing 60-70 kilograms. The material experts were eight nationally licensed trainers and two academics with Doctoral degrees in tennis scientific specifications. Instruments used in this study were spider run test and Guttman scale questionnaire. Data were analyzed by CVR and Friedman formulas. Stage (1) define, conducting a study of relevant articles as a basis for finding problems; stage (2) design, designing HITT specific programs, arranging questionnaires for material expert instruments; stage (3) development, refining program arrangement, and assessing programs, by experts, with Delphi techniques; stage (4) dissemination, disseminating programs and conducting effectiveness tests. **Results:** It is known that the assessment items from 10 material experts show the content validity of 1.00. It is known that the effectiveness test of significance value is 0.000 < 0.05. **Conclusion:** HITT specific program has good content validity, and the effectiveness test can be said to have a significant difference in increasing the reactive agility of wheelchair tennis athletes.

Key words: HIIT Specific, Reactive Agility, Wheelchair Tennis

INTRODUCTION

Physical disabilities are one of the interesting studies to discuss, in addition to mental and intellectual disabilities. Physical disability is a disruption of physical functions that causes paralysis and loss of limbs (Wilson & Clayton, 2010). It is caused by being paralyzed at birth or having an accident resulting in permanent disability (Wilson & Clayton, 2010). Discussing physical disability from a sports perspective is meaningful. Participation of individuals with physical disabilities in exercise needs to be appreciated, especially when they want to excel in the field of sports.

One of the sports that is followed is wheelchair tennis (Rietveld et al., 2021). The participation of wheelchair tennis shows the rapid development of athletes and coaches (Rietveld et al., 2021). It means that there are huge interest and struggle to become an athlete. Participation in wheelchair tennis can be from individuals who were born with disabilities and then learn to play tennis or individuals who were once normal and then permanently physically disabled. Despite the physical limitations, wheelchair tennis athletes still optimize their physical condition through exercise with a systematic program.

It is certainly the task of a coach to create a good and correct training program so that the performance of wheelchair tennis athletes can be optimal. The core abilities of trainers can be explained into four aspects, namely management skill, leadership skill, analysis skill and teaching skills (Gill, 2014). One of the definitions of the teaching skill aspect is that the coach is able to master theoretical and practitioner knowledge. Therefore, ideally the coach is someone who has to learn in theory well and used to be an athlete so that he can understand the situation on the field. Developing training programs must have extensive knowledge, so that train-

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ers can innovate but in accordance with training guidelines. Moreover, the programming of physical conditions must certainly be adjusted to the characteristics of the sport and the type of disability (Yulianto & Yudhistira, 2021).

The physical aspect of wheelchair tennis is important. Physical components are such as endurance, strength, speed, power and agility (Hadi et al., 2022). Agility is one of the most important physical factors in wheelchair tennis (Noroozi et al., 2020). Another definition of agility says that it is the ability to change direction quickly in a relatively short time (Paryadi et al., 2023; Simanjuntak et al., 2022; Zemková & Hamar, 2014). However, the modern definition of agility is the ability to change the direction of motion quickly in the presence of a stimulus, so it is called reactive agility (Zemková, 2016). The fact in the field shows that wheelchair tennis players require reactive agility. When wheelchair tennis players move forward, sideways and backward with an attack from an opponent, of course, reactive agility plays a role. In addition, the characteristics of movement in wheelchair tennis are intermittent, meaning that there is fast movement, but there is a pause. Therefore, programming to increase reactive agility must be adjusted to the training method with intermittent characteristics. One suitable method is the high-intensity interval training (HIIT) method. HIIT is a complex physical exercise method involving high intensity with a short recovery phase (Buchheit & Laursen, 2013).

Studies examining the HIIT method certainly exist, such as the physiological and performance effects of HIIT training on tennis players (Durmuş et al., 2023), the combination of HIIT training with cognitive tasks to increase mental fatigue of tennis players (Díaz-García et al., 2023), HIIT training to increase normal tennis reactive agility (Alim et al., 2021), the effect of badminton specific program training to increase aerobic capacity, anaerobic strength and reactive agility (Wee et al., 2019), effects of HIIT to increase power, endurance, and agility in karate (Hadi & Yudhistira, 2023), the validity of the contents of circuit training programs to increase the aerobic endurance of wheelchair tennis players (Yulianto & Yudhistira, 2021), the validity of the contents of HIIT training programs to increase the specific physical components of karate athletes (Yudhistira et al., 2021), exercise programming to improve the physical aspect of football players (Hidayati et al., 2022).

The studies focused more on normal badminton, football, karate and tennis players. In addition, it focuses on assessing HIIT from physiological and psychological impacts only. Although several articles discussing HIIT to improve physical condition, and empirically to increase reactive agility in wheelchair tennis have not received special attention. In line with previous studies, training programs tailored to people with disabilities have not received optimal attention (Dehghansai et al., 2017). Exercise programs should be drafted explicitly to improve the athletes' performance (Alver et al., 2017). Therefore, this study serves to fill the gap of previous research with the aim of creating an innovation of HIIT-specific training programs to increase the reactive agility of wheelchair tennis athletes. It is expected that this study contributes significantly to the training programming of wheelchair tennis athletes to increase reactive agility.

METHOD

Research Design

In this research, the research development approach was used because it strives to observe and learn more so as to get new concepts. In addition, the research development process is an effort to develop or validate a product and concept so that it is used to answer the problems being faced (Pradipta et al., 2023; Wulandari et al., 2023). The research development used in defining, designing, developing and disseminating, often referred to as 4D (Muwaffaqoh et al., 2021).

Participants

The first stage in the research development (Stage 1) defines conducting a needs analysis in the form of relevant article documents as material for rationalizing the problem so that a problem is found that can be raised as a research topic—stage (2) design, designing a HIIT-specific training program. The design of the training program is arranged based on the needs of wheelchair tennis athletes, namely optimizing the upper and middle extremities—stage (3) develop, which is to refine training programming innovations carefully. Furthermore, the authors compiled a Guttman scale questionnaire as a tool to assess the program. Then, after the program and questionnaire were completed, the author assessed the training program with the help of eight nationally licensed wheelchair tennis coaches and two academics with Doctoral degrees with specialization in tennis coaching. The data collection technique is Delphi, which is to meet experts one by one (Wilpers et al., 2021). In this stage, ten experts assess the training program until a mutual agreement occurs with the assessment of the Content Validity Ratio formula (Ayre & Scally, 2014). Stage (4) disseminate, meaning that programs that are already valid in content are tested for effectiveness using experimental methods.

Experiment was conducted with one-group pre-test-posttest design approach. The population was 30 male and female wheelchair tennis players. The population was taken using the purposive sampling technique. The criteria were (1) wheelchair tennis players who have trained for two years, (2) were willing to participate in a training program for 24 meetings, (3) were not in pain, (4) had participated in a competition event at least at the provincial level. Then, it was found a sample that met the criteria of 20 people; ten male and ten female, aged 28-36 years, weighing 60-70 kilograms. Test instrument used to measure reactive agility was spider run test (Huggins, 2017). For the data analysis, it was used Friedman test analysis or consecutive analysis to see the first test, the second test and the third test. The study was conducted according to the Declaration of Helsinki, and the University's Research Ethics Committee approved the experimental protocol.

Procedure

Training program implementation procedure

- The implementation of the HITT training program is carried out in the tennis field

- Other infrastructure facilities needed are whistles to provide instructions, medicine balls weighing 1-2 kilograms, high and low cones, plaster to provide signs, barbells weighing 1-2 kilograms, and resistance bands.
- Athletes are collected and given directions related to what exercises are carried out; in this case, the researcher provides examples directly from the first post to the last post
- Before entering core exercises, wheelchair tennis players are guided to do warm-ups for 10-20 minutes, including dynamic static stretching and special stretching.
- The researcher is assisted by three research assistants for the smooth running of the treatment
- The training dose setting must be adjusted; for example, when the working time is longer, the interval is at least the same as the working time, or the interval is longer, recovery can also be (Table 1)

Training model description

- Y dynamic run: The wheelchair tennis athlete runs through three cones behind the wheelchair that are loaded using a resistance band held by the coach. The athlete runs when he/she hears the signal, and after passing the third cone, the coach releases the weight on the rubber approaching the raised flag.
- Reactive obstacle ball: The athlete stands in front of the coach, a distance of three meters (ball thrower), and the coach throws the ball in the direction of the throw. The athlete stands in the middle of three meters distance between the obstacles, the athlete is directed to catch the ball quickly. The athlete is required to perform movements in the direction of the ball, and after catching the ball, run past the obstacle.
- Zigzag run & ball reactive: Zigzag run with a distance of one meter. There are six cones, and it ends with the Shake athlete left and right on the chair. Prepare to chase the tennis ball as quickly as possible thrown by the coach to a previously unknown athlete and return to the previous endpoint. It is performed three times.
- Obstacle Reactive agility shadow: Reactive exercise that passes through six obstacles by using a racket and doing shadow at a predetermined point. Athletes listen to the coach's signal to run to the cone mentioned by the coach immediately, then shadowing the basic technical movements of hitting the tennis ball and returning to the starting line.
- T dynamic run and back: The implementation is at the starting line, making one stroke of the wheelchair forward and backwards while waiting for a signal from the coach to run forward through the cones that have been arranged.
- Side arm medicine ball throw: Throw the medicine ball from the starting line, starting from the right and left like a forehand backhand movement with a two-kilograms-medicine ball
- Reactive with ball: Prepare at the starting line by moving the wheelchair to the right and left, and the feeder prepares to pass in a different direction and is caught by the wheelchair athlete.
- Shake left and right on the chair: The wheelchair movement is shaken/pulled to the right and left
- Hexagon obstacle: movement through the sides of a hexagon of a certain size with a forward movement towards the center of the hexagon obstacle and backwards out of the hexagon obstacle
- Run and back forth: back and forth movement three times with a wheelchair. Forward three times pedaling and backward three times pedaling in a wheelchair

Statistical Analysis

The data analysis of this study was quantitative. Data analysis to develop HITT programming innovations used the Content Validity Ratio formula from Lawshe (Aiken, 1985; Nasrulloh et al., 2022; Pradipta et al., 2023). Then, data analysis to see the distribution of general data from the results of the effectiveness test used descriptive analysis that presents the results of maximum, minimum, mean and standard deviation values. Then, the hypothesis test used an alternative Friedman analysis from Repeated Measures ANOVA (Hodges et al., 2018). The researchers used a nonparametric test because the distribution of data is abnormal, so the author uses an alternative nonparametric test. Data analysis was assisted using Excel and SPSS version 23.

RESULTS

Content Validity

Based on the assessment of 10 material experts, the innovation of HIIT exercise programming to improve the reactive agility of wheelchair tennis players has good content validity. It can be seen from the calculation of the Content Validity Ratio (CVR) formula of all question items to obtain a value of 1.00. Therefore, the HITT programming innovation compiled is essential. Based on the results of this data analysis, the program can be implemented for wheelchair tennis athletes to increase reactive agility. The results of the content validity analysis are presented in Table 2 as follows:

Hypothesis Testing

Descriptive analysis results

Based on the results of the descriptive analysis in Table 3, it can be interpreted that the minimum value of test 1 is 26.55, test 2 is 25.45, and test 3 is 23.90. Then, the maximum score of test 1 is 35.90, test 2 is 34.90, and test 3 is 33.90. While the mean test value of 1 is 29.57, test 2 is 28.64, test 3 is 27.24. Last is the standard deviation of test 1 is 3.05066, test 2 is 3.18466, and test 2 is 3.34913. Furthermore, the average difference between test 1 and test 2 is 0.93, then the average difference between test 1 and 3 is 2.33 seconds. Based on the effectiveness test of the three tests in a row, there was a significant increase in the reactive agility of wheelchair tennis athletes.

Friedman test analysis results

Based on Friedman's analysis in Table 4, it can be observed that the Asymp. sig value is 0.000<0.05. It means that there is a difference in the average increase in agility in the three groups of measurement time intervals. Therefore, it can be described that HIIT-specific programming innovations can significantly improve the reactive agility of wheelchair tennis athletes.

Table 1. HIIT-specific programming to improve the reactive agility of wheelchair tennis players

Meeting	Training Item	Training Dose
1-8	Post 1: Y dynamic run Post 2: Reactive obstacle ball Post 3: Zigzag run & ball reactive Post 4: Run & dynamic reactive Post 5: Obstacle reactive agility shadow Post 6: T dynamic run and back	Method: HITT Intensity: Maximum Frequency: 2-3x Working time : 10-15-20-25 seconds so on Set: 2-3-4-5 so on Interval: 10-15-20 seconds so on Recovery: 1-2-3-4-5 minute
9-16	Post 1: Side arm medicine ball throw Post 2: Overhead medicine ball throw Post 3: Reactive with ball Post 4: Shake left and right on the chair Post 5: Hexagon obstacle Post 6: T dynamic run and back	
17-24	Post 1: Zigzag run & ball reactive Post 2: Shake left and right on the chair Post 3: Run and back forth Post 4: Side arm medicine ball throw Post 5: Reactive with ball Post 6: Hexagon obstacle	

DISCUSSION

This study aims to develop HIIT-specific programming and test the effectiveness of reactive agility of wheelchair tennis athletes. The results of the content validity test using the content validity ratio (CVR) formula obtained an assessment from ten experts to get a value of 1.00, which is said to be essential. Therefore, HIIT-specific programming to increase reactive agility has good content validity. The validity of the contents close to 1.00 is almost perfect (Hidayati et al., 2022; Wibowo et al., 2022). Another study stated that the ratio value with an indicator score of 1.00 can be interpreted as having high content validity (Ayre & Scally, 2014), while Hendriyadi stated that the greater the content validity, the more essential the content validity or it can be said to be high (Hendryadi et al., 2017). It is strengthened by Yudhistira in his research stated that the exercise model if validation is carried out to obtain the validity of the overall content is 08.00 to 1.00, can be said to be content-worthy and have good content validity (Yudhistira, 2023). Therefore, HIIT-specific programming is suitable for programming wheelchair tennis athletes specifically to increase reactive agility.

The results of the descriptive analysis of the initial test were carried out after the treatment of eight meetings with an average value of agility of 29.57. The second test was carried out after the treatment of 16 meetings with an average value of agility of 28.64, and the third test was carried out after the treatment of 24 meetings with an average value of agility of 27.24. When viewed from the first, second, and third tests, there was an increase in the aspect of agility, which can be seen from the smaller time value. In addition, the results of the first and second test differences were 0.93, while the difference between the first and third tests was 2.33

The results of the Friedman analysis found that the Asymp.sig (2-tailed) value obtained 0.000<0.05 so that there was a difference in the average increase in agility in the three groups of measurement time intervals. Some studies state that if the significance value is less than <0.05, it can be said that there is a significant difference (Pramono et al., 2023; Purnawan et al., 2022; Saifu et al., 2021; Sulistiyono et al., 2021; Yudanto, et al., 2022; Yudanto et al., 2022). Therefore, it can be described that HIIT-specific programming

Table 2. Results of content validity analysis of hiit specific programming ratio

No	Indicator	Assessor Number										CVR
		1	2	3	4	5	6	7	8	9	10	
1	Models arranged according to the needs of the upper and middle extremity muscles	1	1	1	1	1	1	1	1	1	1	1.00
2	Training model in accordance with the essence of reactive agility	1	1	1	1	1	1	1	1	1	1	1.00
3	The training model prepared is quite varied	1	1	1	1	1	1	1	1	1	1	1.00
4	The exercise model compiled is safe to use	1	1	1	1	1	1	1	1	1	1	1.00
5	The number of training posts is in accordance with the training guidelines	1	1	1	1	1	1	1	1	1	1	1.00
6	The frequency of training is in accordance with HIIT-specific training guidelines	1	1	1	1	1	1	1	1	1	1	1.00
7	The intensity of the exercise is in accordance with HITT's specific guidelines	1	1	1	1	1	1	1	1	1	1	1.00
8	Training intervals are in line with HITT's specific guidelines	1	1	1	1	1	1	1	1	1	1	1.00
9	Training recovery is in accordance with HITT guideline specifics	1	1	1	1	1	1	1	1	1	1	1.00
10	Training work time is in accordance with HITT-specific guidelines	1	1	1	1	1	1	1	1	1	1	1.00

Table 3. Reactive agility descriptive analysis results

Variable	N	Min	Max	Mean	Std. Dev
Reactive Agility Test 1	20	26.55	35.90	29.57	3.05066
Reactive Agility Test 2	20	25.45	34.90	28.64	3.18466
Reactive Agility Test 3	20	23.90	33.90	27.24	3.34913

Table 4. Friedman test results

Test	Mean Rank	Asymp. Sig	Description
Reactive Agility Test 1	2.95	0.000	There is a significant difference
Reactive Agility Test 2	2.00		
Reactive Agility Test 3	1.05		

innovation can significantly improve the reactive agility of wheelchair tennis athletes.

The HIIT-specific training programming has training models that spur to move in a reaction and change direction quickly. Therefore, the combination of HIIT methods in which there is an action, reaction and change of direction training model can increase the reactive agility of wheelchair tennis athletes. Many studies have examined the efficacy of HIIT training in improving physical condition, but in general, HIIT training is more famous for improving endurance and speed related to running (Sabag et al., 2022; Kolly & Panagiotou, 2015; Nugraha & Berawi, 2017). Moreover, in the field of wheelchair tennis, of course, there is still sparsely studied. Hence, the innovation of HIIT-specific programming makes a meaningful contribution to increasing the reactive agility of wheelchair tennis athletes.

Agility in normal tennis is a change in the direction of the foot, shifting from one position to another position quickly. However, in wheelchair tennis, the agility needed is to optimize the upper extremities to move the wheelchair quickly and briefly. Therefore, in particular, the normal tennis training program must be different from wheelchair tennis. In addition, the characteristics of tennis are that the movement is fast and there is a pause, so the training method used must be adjusted to these characteristics. Likewise, it is similar to wheelchair tennis. Although the only thing that moves is the upper extremity, it is still required to move quickly. It means that the upper extremities play a complex role, namely in moving wheelchairs and performing techniques. Therefore, the method that is in accordance with the characteristics of motion and energy systems is high-intensity interval training (HIIT). The HIIT method is believed to improve physical condition, especially in sports which are acyclic movements, or movements characterized by hitting, kicking, throwing, hopping and jumping (Bompa, 2019).

The specific training method of HIIT with specific training models is certainly a very suitable combination to improve the agility of wheelchair tennis athletes. In line with other studies, the HITT method with the contents of the exercise model is that plyometrics can improve endurance, speed and agility (Fajrin et al., 2018). A study from Kabdwal et al. tested high-intensity training combined with explosive training had a significant effect on the agility of young football players (Kabdwal et al., 2023). It is reinforced by another study which says that HIIT exercises combined with specific drill techniques had a significant effect on the agility of young tennis players (Claus et al., 2016).

In general, HIIT is an exercise that contains fast movements with repeated pauses adjusted to the demands of their respective sports (Buchheit & Laursen, 2013). The HIIT method can be combined with technical exercises, self-weight training and outdoor weights (Yudhistira et al., 2021). The energy system used in HIIT exercise is glycolysis and oxidative system. In addition, HIIT is carried out in a relatively short time, between 10 to 30 minutes, because exercise requires high intensity. Of course, the volume of exercise must be adjusted well so that overtraining does not occur (Buchheit & Laursen, 2013). HIIT training has a positive impact on the physical performance of aerobic and anaerobic metabolism and functional performance (Buchheit & Laursen, 2013). HIIT-specific programming empirically exerts a significant influence on the reactive agility of wheelchair tennis athletes.

Limitations

This research still has some shortcomings, namely there is not only one physical components in wheelchair tennis, meaning that the data taken can be physical components of endurance, speed, power and so on. In addition, in this experiment, there was no comparison group, only comparing pretests and posttests in similar groups. The researchers expect that this study contributes to the field of programming specifically for wheelchair tennis coaches and practitioners to serve as the basis for science-based exercises. In addition, the researchers also hope that the next researcher can refine the shortcomings of this study.

CONCLUSION

Based on the results and discussion, it can be concluded that the specific programming of High-Intensity Interval Training to improve the reactive agility of wheelchair tennis athletes has good content validity. Furthermore, based on the effectiveness test of the three tests in a row, there was a significant increase in the reactive agility of wheelchair tennis athletes.

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