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REVİEW

The Effect of the Physical Activity and Exercises on the Cardiovascular System of Individuals with Down Syndrom

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Abstract
Individuals with Down syndrome seem to be more likely to have congenital heart disease (CHD). This situation has led to the need to investigate the effects of exercise and physical activity practices for adults with Down syndrome and to present the results by bringing them together. Because people should be aware of what kind of effects on the heart adults with Down syndrome will be exposed to before exercising. In this study, which is a systematic review study, the results of the studies published online were brought together and the problem situation was determined. Data collected from Web of Science and Google Scholar databases were evaluated according to the PRISMA flowchart. As a result, there are studies in which low-intensity and regular exercises have positive reflections on the cardiovascular systems. However, since there are studies showing that adults with Down syndrome have weaker cardiovescular systems, it can be thought that high-intensity exercises may force the cardiovescular systems of adults with Down syndrome and this may have negative consequences. Therefore, these factors should be considered when planning physical activity and exercise for adults with Down syndrome.

Keywords
Cardiovascular, Down Syndrome, Exercise, Physical Activity

INTRODUCTION

When the probability of people coming to the world with DS (Down syndrome) is examined, it is estimated that this figure is 1-2 per 1000 live births (Baird & Sadovnick, 1987; Frid et al., 1999; Weijerman et al., 2008). It is known to be the most common chromosomal abnormality seen in infants with DS and is a genetic condition associated with congenital heart disease (CHD) such as 22q11-deletion syndrome, Noonan syndrome, Turner syndrome and Williams syndrome (Gorlin et al., 2001; Youngson et al., 2023). This syndrome is caused by trisomy of chromosome 21 (Versacci et al., 2018). Clinical studies for individuals with DS show that; these individuals have developmental delays, facial anomalies, chronic heart diseases, and gastrointestinal malformations (Pueschel, 1990). At the same time, approximately 50% of individuals with DS are diagnosed with CHD and this is the main cause of mortality (AAP, 2001). While the average life expectancy for individuals with DS was 12 years in the 1940s, it has increased to 60 years after the 2000s (Bittles et al., 2007). Despite this statistic, it is known that infant deaths occur 5-8 times more in DS individuals compared to the general population (Weijerman et al., 2008), and the reason for this is CHD (Vis et al., 2009).

The prevalence of CHD is higher in individuals with DS (Marino & De Zorzi, 1993). Since 45-50% of all newborns with Down syndrome have a cardiac anomaly, cardiac screening is routinely recommended (AAP, 2001). It is also seen that individuals with DS in the

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community have lower cardiovascular endurance (Fernhall et al., 1996; Graham & Reid, 2000). The main causes of this situation are sedentary lifestyle, weakness in the muscles, problems with circulation and low maximal heart rate (K. H. Pitetti & Boneh, 1995).

It is conceivable that poor cardiovascular condition may pose a risk for physical activities in individuals with DS, as in all people (Rimmer et al., 2004). Although this problem considers whether it is dangerous for individuals with DS to participate in regular physical activities, there are studies showing the positive effects of cardiovascular exercises for individuals with DS. However, physical activities that suddenly increase the heart rate can also negatively affect individuals with DS due to the greater likelihood of CHD. In general, nevertheless, studies speak of a positive association of exercise with different types of ailments. So that; It is known that regular physical activity has a positive effect on adults with immunodeficiency virus or acquired immunodeficiency syndrome (O'Brien et al., 2010), people with rheumatoid arthritis (C. Van den Ende et al., 1998), and people with mild to moderate heart failure. It has also been reported that physical activities aimed at improving the cardiovascular system significantly reduce mortality for people with coronary heart disease (Jolliffe et al., 2001). At the same time, it is seen that cardiovascular exercise programs have a positive effect on endurance and maintaining physical activity (Rees et al., 2004). Therefore, the aim of this research is to reveal how physical activity affects individuals with DS. Therefore, within the scope of the research, the studies in the literature were examined by making a systematic review and the effects of different physical activity programs on individuals with DS were evaluated.

MATERIALS AND METHODS

The study method was determined as a systematic compilation in order to present the current information to the reader in an impartial way, and the PRISMA flow chart was used as a method (Green et al., 2006; Gulpinar & Gucal Guclu, 2014; Moher et al., 2009).

According to the inclusion and exclusion criteria, 20 studies involving subjects with adult DS were included and were generally randomized clinical trials.

Data Collection Process

Data collection in this study consists of the following processes:

1.Literature determination,
2.Literature review,
3.Literature selection based on specified eligibility criteria,
4.Determining the studies to be included in the research.

For the first phase, a literature review was conducted for articles published from January 1992 to October 2022. Printed and electronic publications are the most common methods of publishing scientific research today. However, electronic publication of research carried out with the influence of technology is more practical for accessing information. Therefore, within the scope of the research, the researches made by scanning the keywords "down syndrome, cardiovascular and exercise" in Web of Science and Google Scholar databases were determined. A long period of 30 years has been chosen in order to include general information chronologically and to see the information updates over time. Searching the Web of Science database using keywords, 145 articles were found. While 4230 studies appeared in the Google Scholar database, a total of 182 studies were examined according to inclusion and exclusion criteria.

Criteria of Inclusion in the Research

- Studies containing keywords.
- English publications.
- The sample group is DS.
- Studies proving the cardiovascular effects of exercise practices in DS individuals.
- Studies involving DS individuals aged 18 and over.

Criteria of Exclusion in the Research

- Studies in which the cardiovascular effects of different types of exercise in DS have not been proven.
- Repetitive works.
- No research papers.
- Studies without a suitable sample group.

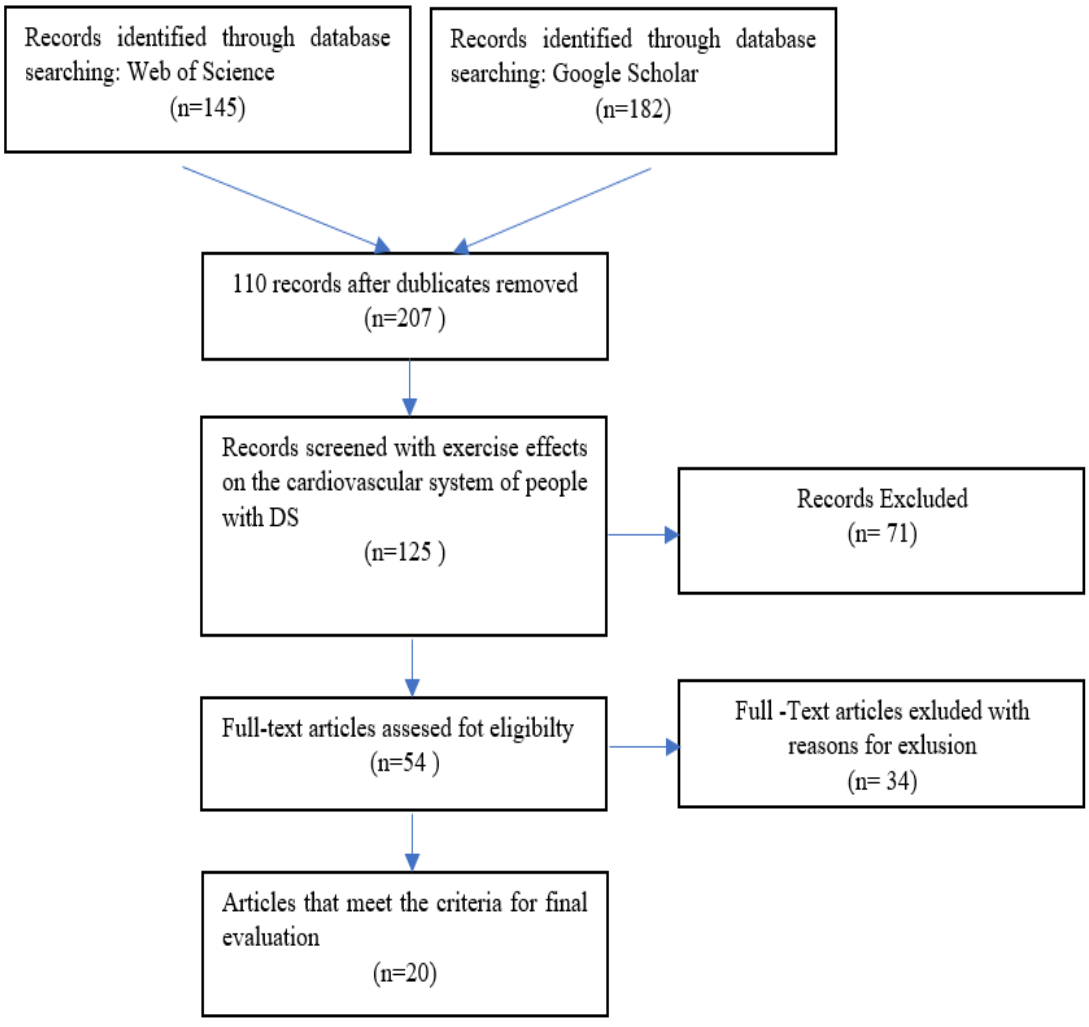

Figure 1. PRISMA Flow Chart (Moher et al., 2009)

RESULTS

Table 1. Studies on the Effects of Different Exercises and Physical Activities in Adults with DS

Reference	Study design, level of evidence	Participations (Age range and diagnosis)	N	Intervention Description	Frequency/ Duration	Conclusion
(K. H. Pitetti et al., 1992)	RCT	Adults with DS Mean Age:25.8±4 Adults without DS Mean Age:23.6±3	32	Treadmill and Schwinn Air-Dyne ergometer	5 hour/5 days in a week	Results showed that cardiovasculer capasitys of individuals with DS were inferior to their peers without DS.
(Millar et al., 1993)	RCT	Adults with DS Mean Age:17.7 CG: n = 4 IG: n = 10	14	Walking/running training program at 65-75% peak heart rate intensity	10 weeks 3 hours in a week & 30 min	After training, both the control and experimental groups showed no change in heart rate.
(K. H. Pitetti & Boneh, 1995)	RCT	Adults with DS Mean Age Male/Female 25.9±4 / 28.4±4 Adults without DS Mean Age 23.1±3/27.1±2	37	Treadmill and isokinetic dynamometry tests.	NR	The results showed significant positive associations between VO2peak and isokinetic leg strength overall. This relationship is an important result for subjects with DS.

Table1. Continued

Reference	Study design, level of evidence	Participations (Age range and diagnosis)	N	Intervention Description	Frequency/ Duration	Conclusion
(Fernhall et al., 1996)	RCT	Adults with & without DS Mean Age: NR	111	Treadmill	1-3 Minutes	Individuals with DS. have even lower peak VO2 levels than their non-Down syndrome peers; this finding is likely attenuated by the lower peak heart rates of individuals with DS.
(Balic et al., 2000)	RCT	Adults with DS & sedentary people Mean Age:18-29	27	Treadmill and isometric strength tests, explosive power, body composition.	1 year 4.9 hours per week	Peak oxygen consumption and muscle strength of the exercise group were significantly higher than the other group.
(Varela et al., 2001)	RCT	Adults with DS Mean Age:21.4 IG: 8 CG: 8	16	Treadmill and rowing ergometer.	16 weeks 5-6 hours per week	The results showed that the exercise training program had no effect on the cardiovascular systems of young people with DS. However, it has been observed that there is a factor affecting exercise endurance and working capacity.
(Tsimaras, 2003)	RCT	Adults with DS Mean age = 24.6 IG: 15 CG: 10	25	Treadmill tests	12 weeks	Significant improvements were seen in physiological parameters of VO2 peak, VE peak and peak for fatigue duration for the experimental group. No significant improvement was seen in the highest physiological parameters in the control group. It was concluded that adults with Down syndrome were able to improve their aerobic capacity when they followed a systematic and well-designed aerobic training program.
(Rimmer et al., 2004)	RCT	Adults with DS Mean Age:39.4 IG: 30 CG: 22	52	Cardiovascular and strength exercise	12 weeks 3 days in a week Cardiovascular (30 min) and strength exercise (15 min)	The cardiovascular fitness and muscular strength and endurance of the training group improved significantly compared to the control group, and there was a slight but significant reduction in body weight.
(Climstein et al., 2008)	RCT	Adults with DS Mean Age:26.1±3 Adults without DS Mean Age:24.4±3	32	Treadmill-graded exercise test	3 day measurements 2 day physical tests	The DS group had a significantly lower peak heart rate compared to the non-DS group. In terms of peak oxygen consumption, the DS group also had significantly lower peak oxygen uptake compared to the non-DS group.
(Mendonca & Pereira, 2009)	RCT	Adults with DS Aged 21-49 Mean Age:34.5±7	12	Aerobic exercise	28 weeks Two 40-min per week	While the body weight and fat percentages of the participants decreased after the exercise, the maximum exercise capacity increased by 27.8% after the training.

Table1. Continued

Reference	Study design, level of evidence	Participations (Age range and diagnosis)	N	Intervention Description	Frequency/ Duration	Conclusion
(Cowley et al., 2011)	RCT	Adults with DS IG:19 Mean Age: 29±9 CG:11 Mean Age:27±7	30	Resistance training	10 weeks 2 days per week	People with DS had a significant increase in leg strength and consequent knee joint strength, and this change was significantly greater than in the control group. In addition, the time of climbing and descending stairs of the intervention group was significantly reduced.
(Oviedo et al., 2014)	RCT	Adults with & without DS IG: 37 (9 with DS) Mean Age: 41 CG: 29 Mean Age: 46	66	Cardiovascular fitness, strength, balance, flexibility and functional ability exercise	14 weeks 3 day in a week, 1 hour/day	The intervention group showed improved cardiovascular fitness, and leg strength. Body weight and body mass index decreased in the intervention group. The control group did not change in any parameter.
(Boer & Moss, 2016)	RCT	Adults with DS Mean age: 33.8±8.6 Continuous aerobic training (CAT) Interval training (IT) Control Group (CG)	42	IT group: 10–30 seconds all out sprints 90 s of low cadence, low intensity cycling or walking. CAT group: Cycling and walking at an intensity of 70–80% of VO2 peak	12 weeks Three times a week	VO2 zirvesi ve tükenme süresi, egzersiz gruplarının ikisi için önemli ölçüde iyileşti. Ayrıca Maksimal kalp hızı ve VO2 değerleri her iki egzersiz grubunda da kontrol grubuna göre önemli ölçüde iyileşti.
(Ringenbach et al., 2016)	RCT	Adults with DS Assisted Cycling Therapy Group (ACT:17) Mean Age: 19.4 ± 4.9 Voluntary Cycling Group (VC:16) Mean Age: 18.4 ± 3.4 Inactive comparison group (NC:11). Mean Age: 17.2 ± 4.3	44	Bicycle exercise.	8 weeks	Although no significant changes were observed for power output and heart rates of the ACT and VC groups, the cadence values of the ACT group were significantly faster.
(Silva et al., 2017)	RCT	Adults with DS Aged 18-60 IG:14 CG:13	27	Wii-based exercise program	2 months 1hour/day and 3 days/week	Wii exercise with various exercise methods has been shown to significantly improve aerobic capacity and lower extremity strength of individuals with DS.
(Suarez-Villadat et al., 2020)	RCT	Children with DS Aged 12–15 IG n=15 CG n=30	45	Recreational swimming program	36 weeks Twice a week for CG three times for IG	It shows that the swimming program has an effect on the body composition of adolescents with DS, which can reduce weight levels and increase exercise capacity.

Table1. Continued

Reference	Study design, level of evidence	Participations (Age range and diagnosis)	N	Intervention Description	Frequency/ Duration	Conclusion
(Beck et al., 2021)	RCT	Adults with DS Mean Age:25 ± 3 Adults without DS Mean Age 24 ± 4	19	Anthropometrics and cardiorespiratory fitness measurements.	30 minuntes of moderately intense physical activity per day	Individuals with DS had significantly lower relative VO2peak and VO2peak corrected for total lean mass (TLM), but had similar absolute VO2peak compared with participants without DS.
(Farías-Valenzuela et al., 2021)	RCT	Adults with DS Mean Age 23.1±3.5 years	15	Motor games	10 months	The applied program showed significant improvements in total body fat, waist circumference, arm circumference and muscle area findings of individuals with DS.
(Oviedo et al., 2021)	RCT	Adults with & without DS Mean Age: 27.3±4	30	Cardiopulmonary exercise test on a treadmill.	Walking: 4 km/h, Slope increased 2.5% every 2 minutes up to 12.5%.	Individuals with DS appeared to have higher Cardiorespiratory coordination (CRC) than participants without disabilities. The findings showed that DS participants had a lower efficiency of cardiorespiratory function during exercise.
(Beck et al., 2022)	RCT	Adults with & without DS Aged 18-40	51	Cardiopulmonary exercise tests	Walking speed at a 0% incline for 2–3min.	The results show that the cardiopulmonary system of individuals with DS has some respiratory, muscular and cardiovascular disorders.

DS: Down Syndrome, MR: Mental Retardation, CG: control group, IG: intervention group, min: minutes, n: number, RCS: randomized controlled study, TD: typically developing, RCT: randomized clinical trial, NR: not reported

DISCUSSION

Studies between the years 1992-2022, which investigated how the exercises performed for individuals with DS affect to their cardiovascular systems, reveal different results. In a study conducted between 16 individuals with and without DS, significant differences were observed for cardiovescular capasity between groups. At the end of the applications using Treadmill and Schwinn Airdyne ergometer, it was seen that individuals with DS had lower quality cardiovescular capacity (K. H. Pitetti et al., 1992). In another study conducted the following year, DS individuals formed the experimental and control group of 14 people. For the experimental group with DS of 10, exercises with a MaxKHR intensity of 65-70% were applied for three days a week and for half an hour. At the end of 10 weeks, it was observed that there was no change in both the experimental and control groups (Millar et al., 1993). This situation shows that there are differences in terms of sample group for studies conducted in similar years. However, similar results may not emerge, as factors such as personal characteristics of individuals, time, place, type of application also differ.

While individuals with DS did not show different results among themselves, they showed more negative results than individuals without disability. In addition to these results, in another study involving individuals with DS and mentally disabled individuals without DS, it was observed that cardivascular coordination was associated with leg strength (K. Pitetti & Boneh, 1995). In another study conducted with 111 individuals with and without DS, some physical tests were applied. The results show that individuals with DS have lower maxVO2 levels, consistent with lower cardiovascular fitness levels. Individuals with DS have even lower maxVO2 levels than their non-DS peers (Fernhall et al., 1996).

Regular strength exercises for athletes with DS can make them stronger than sedentary

individuals without DS (Balic et al., 2000). Likewise, it has been observed that the endurance and working capacity of individuals with DS who exercise regularly are better than those with DS who do not exercise regularly. Fakat cardiovesculer capasitylerinde düzenli egzersizlerin bir etkisi olmayabilir (Varela et al., 2001). However, in favor of individuals with DS, there were significant differences in cardiovescular systems after regular exercises compared to individuals without DS (Rimmer et al., 2004; Tsimaras, 2003). However, even if the state of doing sports differentiates individuals with DS among themselves, the exercises performed gave lower results than those without DS (Climstein et al., 2008). In fact, another study has shown that individuals with DS have lower VO2 capacity than individuals with intellectual disabilities in certain age groups (Baynard et al., 2008).

In another study conducted only for individuals with DS, it was shown that aerobic exercises performed regularly for 28 weeks decreased the body fat percentage of these individuals and increased their maximum exercise capacity (Mendonca & Pereira, 2009). Findings from another study suggest that aerobic capacity and knee extensor strength limit the ability of adults with DS to perform functional tasks of daily living. It can be thought that such different physical parameters affect the daily life of individuals with DS. So much so that Cowley et al. (2010) state that randomized controlled trials should be conducted to test the possible causal relationship between exercises designed to improve physical fitness and functional tasks of daily life. Because it has been reported that individuals with DS give better results in daily activities such as isokinetic knee extensor and flexor and climbing stairs after regular exercises (Cowley et al., 2011). This suggests that individuals with DS may experience possible knee problems together with their body weight, and therefore their daily movements may be restricted. Because it is known that cardiovascular fitness, hand grip strength, leg strength and balances increase, and body weight and body mass index decrease after the training period of individuals with DS who exercise (Oviedo et al., 2014). These changes may enable individuals with DS to perform daily activities with a more appropriate physical mass.

It has been observed that regular resistance and aerobic exercises for individuals with DS also affect blood parameters. Significant reductions in some blood variables were observed after twelve weeks of aerobic and/or resistance training (Seron et al., 2015). This suggests that moderate aerobic and resistance exercises have a chronic hypotensive effect for young people with DS. In another study conducted on individuals with DS by dividing into different exercise groups, submaximal heart rate and VO2 values of individuals with DS who did aerobic exercise and did interval exercise were significantly improved in both exercise groups compared to the control group (Boer & Moss, 2016). In the applications performed in three different groups with DS for cycling activities, it was observed that the heart rate did not differ between the groups, but the bicycle cadence speed of the assisted cycling therapy group was higher. (Ringenbach et al., 2016). It has also shown that exercise games using Wii Fit or other equipment can also be attractive alternatives for adults with DS to engage in regular physical activity, prevent sedentary behavior and reduce the risk of cardiovascular disease (Silva et al., 2017). Thus, different types of exercise that emerged over the years may have different effects for individuals with DS. In addition, the fact that individuals with DS can access different exercises in developing and changing life conditions shows us different results about cardivesculer systems.

Considering the studies conducted in recent years, it has been stated that individuals with DS still have structures prone to arrhythmia even if they do not have congenital heart disease, and that 60 individuals with DS have a higher heart rate than the other 60 non-DS individuals. (Ghandi et al., 2018). However, it is also seen that exercise has a positive effect on physical parameters such as body fat percentage for individuals with DS (Suarez-Villadat et al., 2020). The decrease in body fat percentage can also have a positive effect on the cardiovascular system. Because it has been seen that the simultaneous exercise program applied with motor skill games reduces the body fat ratio and cardiovascular risk of individuals with DS (Farías-Valenzuela et al., 2021).

In another similar recent study, adults with DS showed higher Cardiorespiratory coordination (CRC) dimensionality and a higher measure of entropy than non-disabled participants. Both of these findings point to a lower efficiency of

cardiorespiratory function during exercise in participants with DS (Oviedo et al., 2021). Another study showing that PeakVO2 is higher in individuals with DS during exercise also showed that the relationship between cardiorespiratory and anthropometry fitness found in the general population is not the same in adults with DS and that anthropometry does not fully explain cardiorespiratory fitness in adults with DS (Beck et al., 2021). Another research finding supporting these results stated that adults with DS showed disorders in the cardiovascular, respiratory and muscular aspects of the cardiopulmonary system (Beck et al., 2022).

Conclusion

Studies in the field of medicine regarding the cardivesculer structure of adults with DS show that there are some differences in detail. When the studies on the effects of exercise on the cardiovescular systems for adults with DS are evaluated in general, it has been observed that various effects occur when different exercises are performed regularly. In particular, it is understood that adults with DS have a weaker cardiovescular system compared to other individuals in high-intensity exercises. However, it is thought that other physical parameters of adults with DS may also affect their cardiovescular systems. In general, weak joint and muscle structure with increasing weight reduces the mobility of adults with DS, and this may be the cause of a weaker cardivescular system with a sedentary life. As a result, regular exercises has a positive effect on various physical parameters of adults with DS. Moreover cardiovascular systems of individuals with DS give different results according to the type of exercise. There are studies in which low-intensity and regular exercises have positive reflections on the cardiovascular systems. However, since there are studies showing that adults with DS have weaker cardiovescular systems, it can be thought that high-intensity exercises may force the cardiovescular systems of adults with DS and this may have negative consequences. Therefore, it may be more appropriate to prefer low-intensity aerobic exercises when planning exercise for adults with DS.

Conflict of Interest

No conflict of interest is declared by the authors. In addition, no financial support was received.

Author Contributions

Study Design, Data Collection, Statistical Analysis, Data Interpretation, Manuscript Preparation, Final review and editing, performed by the author.

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