scientific reports

OPEN

Benefits of inclusive sport training on fitness and health of athletes with and without intellectual disability

Maria Chiara Gallotta[1,4]✉, Emanuele Franciosi[2,4], Martina Giorgi[2], Laura Guidetti[3], Eva Cerbara[2], Giorgio Pes[2], Fioretta Silvestri[3] & Davide Curzi[3]✉

Sedentary behaviours in adults with intellectual disabilities (ID) negatively impact health-related determinants and increase the risk of physical dysfunction or chronic health issues. Inclusive sport practice can enhance social inclusion and fitness, benefiting overall person development and life quality. This study aimed to assess fitness level variation in athletes with and without ID before and after a 9-month inclusive (INC) and non-inclusive (N_INC) basketball training. 38 athletes with ID and 14 athletes without ID belonged to INC group, 38 athletes with ID belonged to N_INC group and 23 participants with ID belonged to the control group (CG). Before and after the intervention period, all participants performed anthropometric (body weight, body mass index, body fat percentage) and fitness tests (muscle strength and power, cardiovascular endurance, balance, flexibility, agility, movement speed, and coordination). ID and non-ID athletes of both INC and N_INC groups significantly improved in most of the tests (weight, balance, flexibility, muscle strength, endurance, agility, movement speed and coordination) while CG group significantly worsened weight, muscle endurance, flexibility, agility, movement speed and coordination, after the intervention ($p < 0.05$). These findings showed that sport training improved fitness in athletes with ID, decreasing health risks. Moreover, involving in the same training group persons with and without disabilities, does not limit the beneficial effects that training induce on persons without ID and could be a valid way to promote both social inclusion and physical health of persons with ID.

In the last twenty years, research interest on parasport had growth exponentially likely due to an increase in the number of parasports events and competitions[1]. One of the targeted population includes subjects with Intellectual Disability (ID) as they are generally less active and exhibit higher levels of sedentary behaviours than the average of not-ID population[2,3]. Indeed, Dairo and colleagues[4] showed that about 90% of individuals with ID did not reach the suggested amount of physical activity per week recommended by the World Health Organization[5].

Physical and mental health problems in adults with ID are significantly associated with sedentary behaviours[6] and, consequently, have a negative impact on health-related determinants (i.e. body composition, cardiovascular and muscular endurance, flexibility and muscular strength)[7]. In particular, it has been shown that approximately the 80% of people with ID are overweight or obese and have a body mass index (BMI) higher than the average population[3]. These abovementioned factors may contribute to an increased risk of suffering physical dysfunction, cardiovascular diseases or chronic health problems[8]. Moreover, individuals with ID are likely to show lower level of cardiovascular endurance[9], muscular strength[10], muscle coordination and balance control[11] compared to the general population. Additionally, many individuals with ID have issues with postural stability, movement planning, and speed[12], which could negatively impact on their daily life activities and independence.

Considering the physiological and psychological issues that individuals with ID might cope with, engaging in physical activity and sport activities could represent a valuable tool for both social inclusion[13] and fitness enhancement[14,15], improving their motor, communication, social and cognitive skills[12,16].

[1]Department of Physiology and Pharmacology, Vittorio Erspamer, Sapienza University of Rome, Piazzale Aldo Moro, 5, 00185 Rome, Italy. [2]Sport Association ASD, Forza 4, Rome, Italy. [3]Department of Humanities, Movement and Education Sciences, University Niccolò Cusano, Rome, Italy. [4]These authors contributed equally: Maria Chiara Gallotta and Emanuele Franciosi. ✉email: mariachiara.gallotta@uniroma1.it; davide.curzi@unicusano.it

Several researchers suggested that physical activity and sport intervention programs positively contributed to the overall person development (physical, psychological, cognitive, and social development)[12,16] and life quality improvements in individuals with ID[10,14]. Despite these evidences, Barnes et al.[3] reported that the most common physical activity that a large sample of adults with ID referred to do is merely walking, which might not be sufficient to fulfil the above described social and physiological needs of people with ID when walking is alone without others[17].

Team sports, compared to individual training, could not only improve fitness level but also increase interactions among participants. In the field of parasport research, basketball is the most analysed sport[1] and it has been investigated in several studies with subjects with ID[18–22]. Indeed, basketball practice, which includes many of the basic motor skills such as running, jumping, shooting, change of direction skills and defensive and offensive skills[22], represents an effective training for both cardiovascular endurance[23] and muscular strength[9,20] in population with ID.

Two different settings have been commonly used in basketball training for people with ID: the specific or the inclusive activity. In the first arrangement, sport is designed exclusively for persons with ID, and is based on the protective role of a specific educational institution[24]. On the contrary, in the inclusive setting, people with ID train together with people without ID in the same context[25]. The role of the inclusive context is the promotion of social inclusion throughout the sport activity[26] where athletes with and without ID compete together in the same team, such as in the Special Olympics Unified Sports[19,21,27]. Playing with peers without ID could increase the perception of sport competence in athletes with ID[28] and could improve the self-awareness of their physical limitations[19]. In addition, the inclusive sport practice aims to impact on individuals without disability. Indeed, the first goal of the Unified Sports, is to create a context where all athletes are challenged to improve their skills, regardless of their physical and mental health conditions[19].

Still now, barriers in the development of inclusive fitness contexts are due to prejudices and preconceptions of people without disability[29]. A recent report on perceptions of people without disability about integrated sport, showed that around two thirds of people had no knowledge of what the term 'inclusive sport' means. Moreover, they stated that the major benefit of inclusive activities in people without disability is the social and personal enrichment, whereas individual sport skills and fitness improvement were not mentioned among the hypothetical benefits of inclusive sports[30]. In general, the major concern in people without disability, regarding the integrated sport, is the common thought that training with teammates with ID is less effective than a regular sport environment and could under challenge their training level[31]. Baran and colleagues[32] investigated the effect of 8 weeks of Unified Sports Soccer training in athletes with and without ID. The authors found that the program was effective in increasing fitness and soccer skill performance of all athletes, even if in a more modest degree than those with ID[32].

Although the research on inclusive sport has growth in the last few years, to our knowledge there is a lack of studies that analyse the improvement of both people with and without ID during inclusive sport practice[32,33]. Moreover, some recent reviews showed that only few studies on physical activity and ID the effects of sport interventions on people with ID[34,35], suggesting the need to focus on this assessment area. In addition, studies with long training intervention programs are needed to understand the long-term benefits on fitness improvement in both people with and without ID[7,10].

Thus, this study had three different aims. The first aim was to evaluate the effects of 9-month basketball training on fitness level of athletes with ID comparing non-inclusive setting, inclusive setting and sedentary persons with ID (control group). The second aim was to evaluate the potential role of the inclusive basketball training on fitness level of athletes without ID. The third aim was to assess the correlation of each fitness variable with subjects' ID levels. We hypothesized that subjects with higher ID level have the poorer gross motor control that could affect performance on physical fitness tests, resulting in lower fitness level.

Methods

Experimental approach to the problem

A repeated-measures experimental design was used to quantify the effects of inclusive basketball training intervention on fitness and health of athletes with and without ID. The experimental protocol was conducted in four consecutive steps. In the first step, all subjects with ID underwent a medical-psychiatric examination conducted by a mental health staff to assess their diagnosis of ID, in order to define their level of intellectual functioning and of corresponding functional abilities (i.e., levels of adaptive functioning), and abilities in communicating[36]. Moreover, all participants underwent a compulsory physical examination including a general medical history and sports-related history, with a standardized questionnaire followed by supplementary questioning; a physical examination; an electrocardiogram at rest performed and interpreted by a specialist in sports medicine[37]. The physical examination was performed for determining the participants' athletic eligibility.

In the second step, all subjects were assessed before the specific intervention period (Pre) through fitness and coordinative tests.

In the third step, all players of both inclusive (INC) and non-inclusive (N_INC) groups participated in a 9-month basketball specific training program of 3 h per week (2 times × 90 min). Each basketball training session consisted in four phases which could be adapted following the specific coaches' goals during the same training session (Fig. 1). Each phase required a different type of weight training and conditioning program for players to follow and it was designed to prepare players for the rigours of training and game play[38]. Details on basketball training are described in the Appendix 1. During the same 9 months, the sedentary control group (CG) participated in a recreational and leisure activity program, focused on artistic, logic and/or cooking activities (artistic lab, logic lab and/or cooking lab).

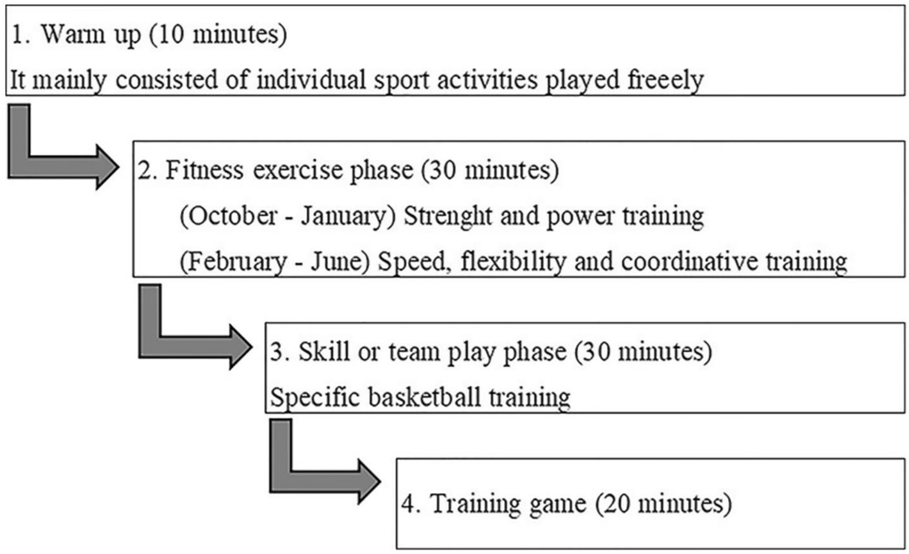

Figure 1. Training session schedule.

In the fourth step, all subjects were assessed after the specific intervention period (Post) through the same fitness and coordinative tests performed in the second phase.

Subjects

A total of 99 subjects with ID (36 females, 63 males) and 14 subjects without ID (5 females, 9 males) volunteered to participate in the study. The 14 athletes without ID and 38 athletes with ID and (no-disability group) were randomly assigned to inclusive sport group (INC), 38 athletes with ID were randomly assigned to non-inclusive sport group (N_INC) and the remaining 23 participants with ID were randomly assigned to the control group (CG; not attending to any sport).

All subjects with ID lived at home or in group settings, and none was institutionalised. They were classified as having mild (28.3%), moderate (29.3%), and severe (42.4%) ID. All participants were recruited from sports clubs (athletes) or social cooperatives in Rome (control group). All athletes had to be exclusively involved in the project "Sport anch'IO" [ME are sports too]. Inclusion criteria were being adults, never having participated in inclusive sporting activities. For participants with ID, having a neuropsychiatric diagnosis of mild, moderate, or severe ID, not having physical and/or sensory disabilities. Exclusion criteria included having profound ID. The study was approved by the Ethics Committee for Transdisciplinary Research (CERT) of Sapienza University of Rome (ricerca ID n. 7/2022 revisione 2 del 20.02.2023) in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Written informed consent was obtained from all participants and from their parents or their legal guardians (if indicated) after a detailed description of the procedures was provided.

Measurements

Before recording anthropometric measurements, fitness and coordinative test scores, all subjects had a variable number of familiarization sessions. The number was related to the speed with which the participants got used to the field tests.

Anthropometric measurements, physical fitness and coordinative abilities were evaluated through modified and validated test battery for individuals with ID. All the tests had a high reliability in people with ID (ICC range 0.90–0.99)[9].

Pre- and post-intervention participants' weight, height, body mass index (BMI) and body fat were assessed. Weight and height were measured using a scale and a stadiometer to the nearest 0.2 kg and 0.1 cm, respectively. Biceps, triceps and suprailiac thickness was measured to the nearest 0.2 mm using a calliper (Harpenden, St Albans, UK) on the right side of the body. All skin folds were taken three times by the same experimenter to ensure consistency in results with the average of the three values used as a final value. To predict body fat (%FM) the equation described by Durnin and Womersley[39] was selected for this investigation.

Pre- and post-intervention participants' physical fitness variables were assessed: cardiovascular endurance (VO_{2max}) (step test), explosive leg power (standing long jump test), hip joint flexibility (sit-and-reach test), forearm muscular strength (hand grip test), upper-body and trunk muscular strength and endurance (push-up and sit-up tests, respectively), and agility and speed of lower limbs (shuttle run 10×5 m test)[9]. Moreover, pre- and post-intervention participants' coordinative abilities were assessed: balance ability (flamingo test), motor coordination (timed up and go test), coordination and speed of upper limbs (plate tapping test)[9]. Details on test protocols are described in the Appendix 2.

Statistical analysis

An a priori power analysis to determine sample size was completed using G*Power 3.1.9.7 software. The Type I alpha (error level) at 5% and a Type II beta (error level) of 5% (or a power of 95%) were set a priori. This analysis showed that for the medium effect size of 0.25 and an error probability of 0.05 with a power of 0.95, the sample size would need to be N = 66. Thus, the target size of the sample recruited for this study was greater than 66 participants. A sample of this size will provide the study with the requisite power needed to provide valid results[40].

Descriptive analysis

All results were expressed as mean ± standard deviation.

Inferential analysis

Individuals with ID. Data were analysed using a mixed-model analysis of variance (ANOVA) with group as between-participants factor and time as within-participants factor. The main effects of group (three levels, INC vs. N_INC vs. CG), time (two levels, pre vs. post) and the interaction between them (time x group) were assessed. Bonferroni post hoc analysis was subsequently performed to interpret data results when significant main effects and interactions were observed. Partial eta squared was used to calculate the effect size of the different variables (partial η^2 = small ≥ 0.01, medium ≥ 0.06, large ≥ 0.14).

A bivariate correlation analysis (Spearman correlation coefficient) was performed to examine the relationship between ID levels (1 = mild, 2 = moderate, 3 = severe) and all parameters measured at baseline and their changes (Δ) following the intervention period.

Individuals without ID. A paired *t*-test comparison was conducted on each variable to examine the intervention effect (pre vs. post) in the no-disability group. Cohen's *d* was used to calculate the effect size of the different variables[41].

Improvement degree (Δ) analysis among trained groups. For each athletes' variable evaluated after the intervention, we calculated the absolute variation (Δ) with respect to its preintervention value (postintervention value—preintervention value). The analysis of variance (one-way ANOVA) was then performed to examine the effect of intervention (three levels, INC vs. N_INC vs. no-disability group) on the absolute variation in each variable, followed by post hoc analysis (Bonferroni adjustment) to determine effects within the three intervention groups.

Statistical significance was defined as $p < 0.05$. Statistical analysis was performed with SPSS Version 27.0 statistic software package.

Results

Individuals with ID

The ANOVA revealed a significant main effect of time on weight, BMI, cardiovascular endurance, balance ability, forearm muscular strength, upper-body strength and endurance, trunk muscular strength and endurance ($p < 0.01$), a significant main effect of group on explosive leg power, forearm muscular strength, strength, upper-body strength and endurance, trunk muscular strength and endurance, agility and speed of lower limbs, coordination and speed of upper limbs ($p < 0.05$) and a significant time x group interaction on weight, %FM, BMI, balance ability, hip joint flexibility, upper-body strength and endurance, trunk muscular strength and endurance, motor coordination, agility and speed of lower limbs, coordination and speed of upper limbs ($p < 0.05$) (Table 1).

Specifically, both INC and N_INC groups significantly improved weight, BMI, balance ability, upper-body strength and endurance, trunk muscular strength and endurance, agility and speed of lower limbs, coordination and speed of upper limbs while CG group significantly worsened weight, BMI, trunk muscular strength and endurance, motor coordination, agility and speed of lower limbs, coordination and speed of upper limbs after the intervention (Table 2).

Explosive leg power and forearm muscular strength were significantly affected by the group regardless of the time, showing that CG performances were significantly lower than INC and N_INC athletes' performances (76.1 ± 38.1 vs. 108.7 ± 41.8 vs. 88.7 ± 52.2 cm; $p < 0.05$ and 16.8 ± 16.6 vs. 40.5 ± 22.8 vs. 38.1 ± 23.2 kg; $p < 0.05$, respectively).

The application of Spearman's correlation analysis indicated that ID level was significantly correlated with 10 of the 13 parameters measured at baseline (Table 3). Moreover, correlation analysis indicated that ID level was positively correlated with the coordinative changes (timed up and go test Δ) following the intervention period ($p = 0.03$, R = 0.28), revealing that people with lower ID obtained higher ability score in motor coordination.

Individuals without ID

No-disability group significantly improved weight, %FM, BMI, cardiovascular endurance, hip joint flexibility, forearm muscular strength, trunk muscular strength and endurance, motor coordination, agility and speed of lower limbs, coordination and speed of upper limbs after intervention (Table 4).

Improvement degree (Δ) analysis among trained groups

Improvement across intervention for each trained group (INC, N_INC, no-disability group) was analysed using absolute variation (Δ). ANOVA revealed that no-disability group showed the higher reduction of %FM comparing with both INC and N_INC groups ($F_{2,80} = 8.48$, $p < 0.001$, $\eta^2 = 0.175$), N_INC group showed the higher improvement of balance ability ($F_{2,64} = 4.10$, $p = 0.021$, $\eta^2 = 0.114$) and upper-body strength and endurance ($F_{2,81} = 3.81$,

Variable	Factors	df	F	p	Partial η^2	Observed power
Weight (kg)	**Time**	**1**	**25.82**	**< 0.001**	**0.219**	**1.00**
	Group	2	0.32	0.730	0.007	0.10
	Time x Group	**2**	**23.96**	**< 0.001**	**0.342**	**1.00**
	Error	92				
FM (%)	Time	1	0.52	0.472	0.006	0.11
	Group	2	1.52	0.224	0.033	0.32
	Time x Group	**2**	**3.17**	**0.047**	**0.066**	**0.59**
	Error	89				
BMI (kg/m^2)	**Time**	**1**	**22.07**	**< 0.001**	**0.195**	**1.00**
	Group	2	0.31	0.737	0.007	0.10
	Time x Group	**2**	**20.37**	**< 0.001**	**0.309**	**1.00**
	Error	91				
Cardiovascular endurance (ml/kg*min)	**Time**	**1**	**12.48**	**0.001**	**0.149**	**0.94**
	Group	2	3.05	0.054	0.079	0.57
	Time x Group	2	1.23	0.298	0.034	0.26
	Error	71				
Balance ability (num)	**Time**	**1**	**16.27**	**< 0.001**	**0.182**	**0.98**
	Group	2	0.42	0.661	0.011	0.12
	Time x Group	**2**	**6.38**	**0.003**	**0.149**	**0.89**
	Error	73				
Explosive leg power (cm)	Time	1	0.96	0.331	0.013	0.16
	Group	**2**	**3.37**	**0.040**	**0.085**	**0.62**
	Time x Group	2	0.93	0.400	0.025	0.21
	Error	73				
Hip joint flexibility (cm)	Time	1	1.02	0.317	0.013	0.17
	Group	2	1.26	0.290	0.032	0.27
	Time x Group	**2**	**3.33**	**0.041**	**0.080**	**0.61**
	Error	77				
Forearm muscular strength (kg)	**Time**	**1**	**8.33**	**0.005**	**0.109**	**0.81**
	Group	**2**	**8.74**	**< 0.001**	**0.205**	**0.96**
	Time x Group	2	2.28	0.110	0.063	0.45
	Error	68				
Upper-body muscular strength and endurance (num)	**Time**	**1**	**20.86**	**< 0.001**	**0.197**	**1.00**
	Group	**2**	**10.76**	**< 0.001**	**0.202**	**0.99**
	Time x Group	**2**	**4.06**	**0.021**	**0.087**	**0.71**
	Error	85				
Trunk muscular strength and endurance (num)	**Time**	**1**	**17.42**	**< 0.001**	**0.165**	**0.99**
	Group	**2**	**13.20**	**< 0.001**	**0.231**	**1.00**
	Time x Group	**2**	**17.52**	**< 0.001**	**0.285**	**1.00**
	Error	88				
Motor coordination (s)	Time	1	2.03	0.158	0.026	0.29
	Group	2	0.61	0.548	0.016	0.15
	Time x Group*	**2**	**3.82**	**0.026**	**0.091**	**0.68**
	Error	76				
Agility and speed of lower limbs (s)	Time	1	3.45	0.066	0.036	0.45
	Group	**2**	**3.84**	**0.025**	**0.076**	**0.68**
	Time x Group	**2**	**34.05**	**< 0.001**	**0.423**	**1.00**
	Error	93				
Coordination and speed of upper limbs (s)	Time	1	0.83	0.364	0.009	0.83
	Group	**2**	**13.14**	**< 0.001**	**0.230**	**1.00**
	Time x Group	**2**	**30.87**	**< 0.001**	**0.412**	**1.00**
	Error	88				

Table 1. ANOVA results in anthropometric, fitness and coordinative ability variables. FM, body fat; BMI, body mass index. Significant values are in bold.

Variables	INC group (*n* = 38)		N-INC group (*n* = 38)		CG group (*n* = 23)	
	Pre	Post	Pre	Post	Pre	Post
Age (years)	35.3 ± 9.3		37.5 ± 12.2		34.4 ± 8.8	
Weight (kg)	75.75 ± 14.87	73.06 ± 14.26**	75.31 ± 17.18	71.83 ± 15.72**	70.47 ± 13.03	72.05 ± 13.37**
FM (%)	26.82 ± 7.57	26.87 ± 7.36	30.28 ± 8.23	29.73 ± 8.35	28.58 ± 7.59	29.61 ± 7.62
BMI (kg/m^2)	28.20 ± 6.03	27.18 ± 5.58**	27.50 ± 5.07	26.22 ± 4.43**	27.48 ± 5.38	28.07 ± 5.36**
Cardiovascular endurance (ml/kg*min)	26.24 ± 5.41	27.42 ± 5.58	23.54 ± 6.20	25.80 ± 5.96	23.15 ± 3.51	23.90 ± 3.43
Balance ability (num)	11.39 ± 13.94	8.32 ± 12.31**	13.80 ± 9.13	10.12 ± 8.65**	12.17 ± 12.69	12.74 ± 8.31
Explosive leg power (cm)	109.39 ± 43.81*	108.00 ± 40.41*	92.89 ± 57.94	84.43 ± 46.47	75.00 ± 30.91	76.68 ± 43.25
Hip joint flexibility (cm)	18.23 ± 9.04	18.03 ± 10.94	14.59 ± 6.55	16.03 ± 8.36	20.28 ± 9.14	16.70 ± 7.08
Forearm muscular strength (kg)	37.57 ± 21.14	43.37 ± 24.28	33.79 ± 21.64	42.36 ± 24.21	13.85 ± 7.76	13.38 ± 10.55
Upper-body muscular strength and endurance (num)	23.03 ± 10.13	28.09 ± 11.37**	15.08 ± 10.07	22.92 ± 11.78**	12.89 ± 8.90	13.50 ± 7.54
Trunk muscular strength and endurance (num)	18.31 ± 7.31	22.86 ± 7.14**	17.12 ± 7.00	22.59 ± 8.42**	12.95 ± 6.29	10.14 ± 7.16**
Motor coordination (s)	13.04 ± 4.02	13.43 ± 5.38	15.22 ± 8.76	14.43 ± 6.91	12.94 ± 3.76	15.12 ± 3.33*
Agility and speed of lower limbs (s)	31.71 ± 11.08	27.87 ± 10.52**	38.27 ± 18.27	35.84 ± 17.73**	36.48 ± 8.23	40.57 ± 10.94**
Coordination and speed of upper limbs (s)	20.06 ± 9.32	17.36 ± 8.34**	22.06 ± 9.86	21.08 ± 9.23**	29.33 ± 7.18	32.22 ± 10.01**

Table 2. Pre- and post-test (mean values ± SD) in INC group, N_INC group and CG group. INC, inclusive sport group; N_INC, non-inclusive sport group; CG, control group; FM, body fat; BMI, body mass index. * $p < 0.05$ post vs. pre; ** $p < 0.01$ post vs. pre.

Variable	ID level
Weight	0.068
%FM	0.247*
BMI	0.175
Cardiovascular endurance	−0.142
Balance ability	0.565**
Explosive leg power	−0.477**
Hip joint flexibility	−0.236*
Forearm muscular strength	−0.282*
Upper-body muscular strength and endurance	−0.410**
Trunk muscular strength and endurance	−0.397**
Motor coordination	0.370**
Agility and speed of lower limbs	0.563**
Speed of upper limbs	0.377**

Table 3. Correlation coefficients between ID level and variables measured at baseline. ID, intellectual disability; FM, body fat; BMI, body mass index. * $p < 0.05$; ** $p < 0.01$.

$p = 0.026$, $\eta^2 = 0.086$) comparing with no-disability group and finally, INC group showed the higher improvement of agility and speed of lower limbs ($F_{2,84} = 3.84$, $p = 0.025$, $\eta^2 = 0.084$) and coordination and speed of upper limbs ($F_{2,79} = 6.69$, $p = 0.002$, $\eta^2 = 0.145$) comparing with no-disability group and N-INC group, respectively (Table 5).

Discussion

Individuals with ID

The first aim of the present study was to evaluate the effects of 9-month basketball training on fitness level of individuals with ID comparing inclusive setting, non-inclusive setting and sedentary people.

Results showed the positive effects of physical activity and sport training on fitness level of subjects with ID since athletes of both INC and N_INC groups significantly improved in most of the anthropometric, fitness and coordinative tests after the basketball training period. In particular, they significantly improved their weight status compared to CG. Thus, these data suggested that physical training could prevent weight gain, a common condition in persons with ID, and also could favour the loss of fat mass. These findings on the positive role of sport training on body weight management in individuals with ID were in line with those of previous studies[9,27,42]. However, the loss of body weight depends on training volume and intervention duration[43]. A more limited intervention time than considered, could not be able to produce a weight or BMI decrease[32]. Conversely,

Variables	No-disability group (*n* = 14)		
	Pre	Post	Cohen's *d*
Age (years)	25.6 ± 4.1		
Weight (kg)	68.71 ± 8.84	66.43 ± 7.49**	0.928
FM (%)	27.82 ± 6.28	24.95 ± 5.78**	1.166
BMI (kg/m^2)	22.81 ± 2.86	22.06 ± 2.48**	0.931
Cardiovascular endurance (ml/kg*min)	27.34 ± 1.63	27.61 ± 1.66*	0.901
Balance ability (num)	0.71 ± 1.07	0.29 ± 0.47	0.351
Explosive leg power (cm)	183.00 ± 31.32	181.07 ± 38.23	0.079
Hip joint flexibility (cm)	34.14 ± 6.75	35.64 ± 5.23*	0.607
Forearm muscular strength (kg)	80.00 ± 9.50	85.36 ± 9.60**	0.992
Upper-body muscular strength and endurance (num)	28.00 ± 4.17	28.64 ± 4.63	0.481
Trunk muscular strength and endurance (num)	35.79 ± 6.80	38.14 ± 6.87**	0.871
Motor coordination (s)	9.93 ± 1.59	8.93 ± 1.49**	1.275
Agility and speed of lower limbs (s)	21.00 ± 2.66	19.57 ± 2.47**	1.311
Coordination and speed of upper limbs (s)	12.21 ± 2.22	9.86 ± 1.51**	1.521

Table 4. Pre- and post-test (mean values ± SD) in no-disability group. FM, body fat; BMI, body mass index. * $p < 0.05$; ** $p < 0.01$.

Variable	INC group	N_INC group	No-disability group
Weight (kg)	−2.69 ± 2.69	−3.48 ± 3.47	−2.29 ± 2.46
FM (%)	0.06 ± 1.86*	−0.55 ± 2.58*	−2.87 ± 2.46
BMI (kg/m^2)	−1.03 ± 1.25	−1.28 ± 1.26	−0.75 ± 0.81
Cardiovascular endurance (ml/kg*min)	1.18 ± 2.5	2.26 ± 3.83	0.26 ± 0.29
Balance ability (num)	−3.07 ± 3.17	−3.68 ± 4.52*	−0.43 ± 1.22
Explosive leg power (cm)	−1.39 ± 25.09	−8.46 ± 23.6	−1.93 ± 24.36
Hip joint flexibility (cm)	−0.19 ± 7.38	1.45 ± 3.9	1.50 ± 2.47
Forearm muscular strength (kg)	5.80 ± 10.82	8.57 ± 16.16	5.36 ± 5.4
Upper-body muscular strength and endurance (num)	5.06 ± 8.65	7.83 ± 9.51*	0.64 ± 1.34
Trunk muscular strength and endurance (num)	4.56 ± 5.61	5.47 ± 5.55	2.36 ± 2.71
Motor coordination (s)	0.39 ± 2.26	−0.79 ± 4.54	−1.00 ± 0.78
Agility and speed of lower limbs (s)	−3.84 ± 4.09*	−2.42 ± 2.14	−1.43 ± 1.09
Coordination and speed of upper limbs (s)	−2.70 ± 2.28§	−0.98 ± 1.78	−2.36 ± 1.55

Table 5. Variation (Δ) of each measured parameter in INC group, N_INC group and no-disability group (mean values ± SD). INC, inclusive sport group; N_INC, non-inclusive sport group; FM, body fat; BMI, body mass index. * $p < 0.05$ vs. no-disability group; § $p < 0.05$ vs. N_INC group.

the sedentary CG increased their weight and BMI. Inactivity and inappropriate eating habits may be the major causes of the weight gain of CG and, in general, of the high obesity rates of individuals with ID that is usually greater among people with ID than those without disability[9].

After basketball training period, athletes showed significant improvements of balance ability, trunk muscular strength, agility and upper-body speed. Previous studies showed that sport and physical activities induced significant improvements in numerous fitness outcomes such as muscle strength[15,20,32,42,44], movement speed[45] static and dynamic balance[42,44], flexibility[42,44], walking speed and agility[44] in people with ID.

Graham and Reid[2], in their 13-year longitudinal study, reported that the magnitude of fitness decrease over time in people with ID is higher than the one expected in the general population. Thus, sport activity plays a crucial role in physical health maintenance slowing down the typical fitness decline of this special population.

Even if the key role of sport participation in people with ID appears widely shared, Cuesta-Vargas and colleagues[46], in their observational study, concluded that there were not meaningfully differences between the sportspeople and non-sportspeople with ID in strength, balance, aerobic fitness, and flexibility. These findings could be explained by measurements issues. In fact, as the authors themselves pointed out[46], using specific tests for people with ID might have led to different results of fitness scores. Thus, according with existing literature[18,47], we suggest that this type of studies should mainly include tests specific for individuals with ID than fitness test batteries used for the general population.

Our findings revealed that people with a low ID level showed better scores in fitness tests than people with severe ID level. These results were in line with previous studies on motor coordination[9], sport skills[18] and muscle strength[48].

Moreover, correlation analysis between fitness performance improvement after intervention and ID level revealed that ID level was positively correlated with changes in motor coordination alone, suggesting that the rate of enhancement in fitness performance after a sport training program seems not to be directly correlated with ID severity. In the literature, there are many works with contradictory results on this topic. Guidetti and colleagues[18] found that after a 4-month basketball training, athletes with mild and moderate ID achieved higher improvements in sports ability compared to individuals with more severe ID. In agreement with them, Wu and colleagues[49] reported that subjects with mild ID showed the highest effectiveness on anthropometric outcomes after a 6-month fitness program. Moreover, Isık and Zorba[50] found that 12 weeks of hemsball training were more effective in increasing the motor proficiency of adolescents with moderate ID compared to peers with mild ID.

The individual response to training could be the key to explain the different improvement rate of athletes with different ID levels.

Individuals without ID

After 9 months of inclusive basketball training, no-disability group significantly improved most of the measured parameters. In particular, subjects without ID showed a significant improvement of their weight status differently from the other intervention groups. Most of the research studies focused on integrated sport reported the effects of sport training in people with ID and did not pay attention on its effects in people without ID[19,25,28] However, Baran and colleagues[32] found no significant changes in body composition of subjects without ID who participated in 8 weeks of integrated soccer training. Authors argued that a longer intervention period was needed to obtain significant changes in body composition parameters. Authors also reported that an integrated soccer program was effective in improving soccer skills performance in both individuals with and without ID[32]. In agreement with them, Castagno and colleagues[21] found improvements in basketball skills after 8 weeks of Unified Sports program in all participants with and without ID. In our study, we did not assess the specific basketball skills, however we supposed that the significant improvement of cardiovascular fitness, flexibility, strength, dynamic balance, agility and motor coordination could positively affect sport performance. Previously, Stanish and Temple[51] found that a peer-guided exercise programme for adolescents with ID was effective in increasing some fitness-related outcomes also in their peers without ID. In particular, they found significant improvements in BMI, arm strength and walking speed of participants without ID after 15 weeks of individualized weight, aerobic and flexibility training together their peers with ID[51]. Despite these positive results in line with the results of our study, it should be considered that the peer-guided inclusive setting is very different from a team sport setting, where all participants play together and interact within the group toward the same goals. Therefore, involving in the same training group individuals with and without ID does not limit but favours the beneficial effects that training induce on people without ID. However, further studies are needed in order to evaluate the effectiveness of inclusive sport training on fitness and on specific sport skills of people without ID.

Improvement degree (Δ) analysis among trained groups

Previous studies have investigated the impact of inclusive and/or non-inclusive settings in physical activity programs for individuals with ID. However, these studies primarily addressed psychological aspects such as perceived social stigma[52], self-esteem[21], and social inclusion[26]. To date, there has been limited research on fitness- or sport-related outcomes within inclusive and/or non-inclusive settings[25,32,51]. Ninot and colleagues[25] analysed the effects of 32 months of integrated and segregated swimming training in adolescents with ID. The study showed a performance improvement over time in both intervention groups with no significant differences between the two settings. Other studies confirmed the effectiveness of integrated sport training in improving sport skills and fitness outcomes[32,51].

Our analysis of fitness tests' variation across intervention revealed a similarity between the two INC and N_INC groups, while the no-disability group showed the higher improvement in some fitness test comparing with INC and N-INC groups. These results suggested that it is the training itself to lead the athletes' performance improvement rather than the type of training setting.

Limitations of the study

Subjects with severe ID could have experienced difficulty in the understanding of some tasks during fitness assessment. Therefore, despite the continuous supervision and feedback provided by trainers and investigators, casual errors in fitness measurements could have arisen. Another limitation of the study is the lack of assessment of sport skills of both people with and without ID. A third limitation results from the lack of assessment of further psychological and social aspects that could be positively influenced by inclusive sport practice. Moreover, no effects of participants' demographic characteristics, cultural sensitivity and environmental factors could be accounted for in the analyses. The relatively small number of athletes without ID and the unequal distribution of males and females within the three intervention groups could have affected the inclusive basketball training. Finally, a limitation results from the lack of assessment of exercise volume and from the lack of monitoring of exercise intensity during basketball training.

Conclusion

Findings of the present study showed that inclusive basketball training improved fitness level of athletes with ID, decreasing health risks. Moreover, our results novelly showed that inclusive sport training induced beneficial effects also on persons without ID.

Therefore, the present study adds new evidences related to the positive impact that sport training could have on physical fitness of population with ID. In fact, regardless of the sport activity setting, 9 months of sport training induced significant improvements in fitness level of individuals with ID compared to sedentary peers with ID. Moreover, considering the positive effects that inclusive sport settings could have for social inclusion, we suggest that inclusive training could be a valid way to promote physical and psychological health of people with ID. Finally, results of the present study showed a significant improvement of fitness and coordinative test also in athletes without ID, going beyond the common thought that inclusive sport settings could be ineffective to enhance fitness level of people without ID. Future studies are needed to investigate different strategies for social inclusion of people with ID through inclusive sport, in order to evaluate the impact that fitness enhancement could have on sport skills during unified sports matches and competitions.

Data availability

The data that support the findings of this study are available from the corresponding author, [MCG], upon reasonable request.

Received: 1 February 2024; Accepted: 2 August 2024
Published online: 11 September 2024

References

1. Liu, T., Wassell, N., Liu, J. & Zhang, M. Mapping research trends of adapted sport from 2001 to 2020: A bibliometric analysis. *Int. J. Environ. Res. Public Health* **19**, 12644 (2022).
2. Graham, A. & Reid, G. Physical fitness of adults with an intellectual disability: A 13-year follow-up study. *Res. Q. Exerc. Sport* **71**, 152–161 (2000).
3. Barnes, T. L., Howie, E. K., McDermott, S. & Mann, J. R. Physical activity in a large sample of adults with intellectual disabilities. *J. Phys. Act. Heal.* **10**, 1048–1056 (2013).
4. Dairo, Y. M., Collett, J., Dawes, H. & Oskrochi, G. R. Physical activity levels in adults with intellectual disabilities: A systematic review. *Prev. Med. Reports* **4**, 209–219 (2016).
5. Bull, F. C. *et al.* World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br. J. Sports Med.* **54**, 1451–1462 (2020).
6. Harris, L., McGarty, A. M., Hilgenkamp, T., Mitchell, F. & Melville, C. A. Correlates of objectively measured sedentary time in adults with intellectual disabilities. *Prev. Med. Reports* **9**, 12–17 (2018).
7. Chanias, A. K., Reid, G. & Hoover, M. L. Exercise effects on health-related physical fitness of individuals with an intellectual disability: A meta-analysis. *Adapt. Phys. Act. Q.* **15**, 119–140 (1998).
8. Lin, P. Y., Lin, L. P. & Lin, J. D. Hypertension, hyperglycemia, and hyperlipemia among adolescents with intellectual disabilities. *Res. Dev. Disabil.* **31**, 545–550 (2010).
9. Guidetti, L., Franciosi, E., Gallotta, M. C., Emerenziani, G. P. & Baldari, C. Could sport specialization influence fitness and health of adults with mental retardation?. *Res. Dev. Disabil.* **31**(5), 1070–1075 (2010).
10. Jacinto, M. *et al.* Prescription and effects of strength training in individuals with intellectual disability—A systematic review. *Sport.* **9**, 125 (2021).
11. Van Biesen, D., Jacobs, L., McCulloch, K., Janssens, L. & Vanlandewijck, Y. Cognitive-motor dual-task ability of athletes with and without intellectual impairment. *J. Sports Sci.* **36**, 513–521 (2018).
12. Torabi, F. & Asi Hormozi, S. Comparison of the impact of body percussion exercises on executive and balance performance in intellectually disabled and healthy girls of ramhormoz city. *Int. J. Sport Stud. Health* **7**(1), 45–53 (2024).
13. Aitchison, B. *et al.* The experiences and perceived health benefits of individuals with a disability participating in sport: A systematic review and narrative synthesis. *Disabil. Health J.* **15**, 101164 (2021).
14. Bartlo, P. & Klein, P. J. Physical activity benefits and needs in adults with intellectual disabilities: Systematic review of the literature. *Am. J. Intellect. Dev. Disabil.* **116**, 220–232 (2011).
15. Jeng, S., Chang, C., Liu, W. & Hou, Y. Exercise training on skill-related physical fitness in adolescents with intellectual disability: A systematic review and meta-analysis. *Disabil. Health J.* **10**, 198–206 (2017).
16. Akbari, S., Hosseinkhanzadeh, A. A. & Akbari, B. The effect of a comprehensive intervention program based on the world health organization's functional assessment outcomes on the functional levels and adaptive behaviors of adolescents with intellectual disabilities. *J. Assess. Res. Appl. Couns.* **5**(5), 116–128 (2023).
17. Brooker, K. *et al.* "We can talk while we're walking": seeking the views of adults with intellectual disability to inform a walking and social-support program. *Adapt. Phys. Activ. Q.* **32**(1), 34–48 (2015).
18. Guidetti, L., Franciosi, E., Emerenziani, G. P., Gallotta, M. C. & Baldari, C. Assessing basketball ability in players with mental retardation. *Br. J. Sports Med.* **43**, 208–212 (2009).
19. Briere, D. E. & Siegle, D. The effects of the Unified Sports Basketball Program on special education students' self-concepts: Four students' experiences. *Teach. Except. Child. Plus* **5**, 1–12 (2008).
20. Tsimaras, V. K. *et al.* The effect of basketball training on the muscle strength of adults with mental retardation. *J. Strength Cond. Res.* **23**, 2638–2644 (2009).
21. Castagno, K. S. Special olympics unified sports: Changes in male athletes during a basketball season. *Adapt. Phys. Act. Q.* **18**, 193–206 (2001).
22. Franciosi, E., Gallotta, M., Baldari, C., Emerenziani, G. & Guidetti, L. Basketball ability testing and category for players with mental retardation: 8-month training effect. *J. Strength Cond. Res.* **26**, 1524–1531 (2012).
23. Boonman, A. J. N., Schroeder, E. C., Hopman, M. T. E., Fernhall, B. O. & Hilgenkamp, T. I. M. Cardiopulmonary profile of individuals with intellectual disability. *Med. Sci. Sports Exerc.* **51**, 1802–1808 (2019).
24. Mladoneczki-Leszkó, D., Surányi, R. & Kelemen, A. Exploring the quality of life of adolescents with Cerebral Palsy participating in conductive education around the Pannonian Basin. *PLoS One* **17**, 1–13 (2022).
25. Ninot, G., Bilard, J. & Delignières, D. Effects of integrated or segregated sport participation on the physical self for adolescents with intellectual disabilities. *J. Intellect. Disabil. Res.* **49**, 682–689 (2005).
26. McConkey, R., Dowling, S., Hassan, D. & Menke, S. Promoting social inclusion through unified sports for youth with intellectual disabilities: A five-nation study. *J. Intellect. Disabil. Res.* **57**, 923–935 (2013).
27. Rubenstein, E. *et al.* Evaluating the potential of Special Olympics fitness models as a health intervention for adults with intellectual disabilities. *Disabil. Health J.* **13**, 100850 (2019).
28. Pan, C. & Davis, R. Exploring physical self-concept perceptions in athletes with intellectual disabilities: The participation of Unified Sports experiences. *Int. J. Dev. Disabil.* **65**, 1–9 (2019).

29. Nikolajsen, H., Richardson, E. V., Sandal, L. F., Juul-Kristensen, B. & Troelsen, J. Fitness for all: How do non-disabled people respond to inclusive fitness centres?. *BMC Sports Sci. Med. Rehabil.* **13**, 1–12 (2021).
30. Johnson, E. Taking part with disabled people: Non-disabled people's perceptions. Activity Alliance, Manchester (2021).
31. Block, M. E. & Zeman, R. Including students with disabilities in regular physical education: Effects on nondisabled children. *Adapt. Phys. Act. Q.* **13**, 38–49 (1996).
32. Baran, F. *et al.* The effects of a Special Olympics Unified Sports Soccer training program on anthropometry, physical fitness and skilled performance in Special Olympics soccer athletes and non-disabled partners. *Res. Dev. Disabil.* **34**, 695–709 (2013).
33. Chen, C. J., Ryuh, Y., Fang, Q., Lee, Y. & Kim, M. The effects of inclusive soccer program on motor performance and sport skill in young adults with and without intellectual disabilities. *J. Dev. Phys. Disabil.* **31**, 487–499 (2019).
34. Pitchford, E. A., Dixon-ibarra, A. & Hauck, J. L. Physical activity research in intellectual disability: A scoping review using the behavioral epidemiological framework. *Am. J. Intellect. Dev. Disabil.* **123**, 140–163 (2018).
35. Burns, J., Carter, A., Draper, S., & Foad, A. Engaging and sustaining people with intellectual disabilities in physical activity: a narrative review of existing evidence. *Int. J. Dev. Disabil.* 1–11 (2022).
36. American Psychiatric Association. *DSM-V-TR Diagnostic and statistical manual of mental disorders (text revision)* 5th edn. (APA, 2013).
37. Löllgen, H., Leyk, D. & Hansel, J. The pre-participation examination for leisure time physical activity: general medical and cardiological issues. *Dtsch. Arztebl. Int.* **107**(42), 742–749 (2010).
38. Baldari, C. *et al.* Using basketball test battery to monitor players with mental retardation across 2 sports seasons. *J. Strength Cond. Res.* **23**, 2345–2350 (2009).
39. Durnin, J. & Womersley, J. Body fat assessed from total body density and its estimation from skinfold thickness: Measurements on 481 men and women aged from 16 to 72 Years. *Br. J. Nutr.* **32**, 77–97 (1974).
40. Cohen, J. A power primer. *Psychol. Bull.* **112**, 155–159 (1992).
41. Cohen, J. Statistical Power Analysis for the Behavioral Sciences. New York, NY: Routledge Academic (1988).
42. Oviedo, G. R., Guerra-Balic, M., Baynard, T. & Javierre, C. Effects of aerobic, resistance and balance training in adults with intellectual disabilities. *Res. Dev. Disabil.* **35**, 2624–2634 (2014).
43. Pescatello, L. S. *et al.* Physical activity to prevent and treat hypertension: a systematic review. *Med. Sci. Sports Exerc.* **51**(6), 1314–1323 (2019).
44. Arslan, E., Ince, G. & Akyüz, M. Effects of a 12-week structured circuit exercise program on physical fitness levels of children with autism spectrum condition and typically developing children. *Int. J. Dev. Disabil.* **68**, 500–510 (2022).
45. Fleeton, J., Sanders, R. & Fornusek, C. Impact of maximal strength training on countermovement jump phase characteristics in athletes with cerebral palsy. *J. Sports Sci.* **40**, 2118–2127 (2022).
46. Cuesta-Vargas, A. I., Paz-Lourido, B. & Rodriguez, A. Physical fitness profile in adults with intellectual disabilities: Differences between levels of sport practice. *Res. Dev. Disabil.* **32**, 788–794 (2011).
47. Cabeza-Ruiz, R. Considerations for the design of a physical fitness battery to assess adults with intellectual disabilities: Preliminary reference values for the SAMU DIS-FIT study. *Int. J. Environ. Res. Public Health* **17**, 1–15 (2020).
48. Cabeza-ruiz, R., Trigo-Sanchez, M. E., Rodríguez-Servián, M. & Gomez-piriz, P. T. Association between physical fitness, body mass index and intelligence quotient in individuals with intellectual disabilities. *J. Intellect. Disabil. Res.* **65**, 1–9 (2021).
49. Wu, C., Lin, J., Hu, J., Yen, C. & Yen, C. The effectiveness of healthy physical fitness programs on people with intellectual disabilities living in a disability institution: Six-month short-term effect. *Res. Dev. Disabil.* **31**, 713–717 (2010).
50. Isık, M. & Zorba, E. The effects of hemsball on the motor proficiency of students with intellectual disabilities. *Int. J. Dev. Disabil.* **66**, 104–112 (2020).
51. Stanish, H. I. & Temple, V. A. Efficacy of a peer-guided exercise programme for adolescents with intellectual disability. *J. Appl. Res. Intellect. Disabil.* **25**, 319–328 (2012).
52. Cooney, G., Jahoda, A., Gumley, A. & Knott, F. Young people with intellectual disabilities attending mainstream and segregated schooling: Perceived stigma, social comparison and future aspirations. *J. Intellect. Disabil. Res.* **50**, 432–444 (2006).

Acknowledgements
The authors are very grateful to the participants and their families who gave their time to the study. We would also like to acknowledge the "ASD Forza 4", "ASD Algida Lazio", "ASL ROMA 2", "Cooperativa Sociale Obiettivo Uomo Onlus", "Cooperativa Sociale ARL Progetto 96", and "Special Olympics Italia".

Author contributions
Conceptualization, data curation, formal Analysis, project administration, writing—original draft, writing—review & editing: MCG, EF. The contribution of these first two authors must be considered equal. Data curation, visualization, writing—review & editing, MG, EC, GP, FS. Methodology, supervision, writing—original draft, writing—review & editing: LG, DC. All authors read and approved the final version of the manuscript, and agreed with the order of presentation of the authors.

Funding
The author(s) reported there is no funding associated with the work featured in this article.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-024-69334-2.

Correspondence and requests for materials should be addressed to M.C.G. or D.C.