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ORIGINAL CONTRIBUTION

Unlocking Activity in Inactive Children: A Gender-Based Comparison of Three Physical Training Interventions

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Abstract— With physical inactivity among schoolchildren emerging as a global health concern, this research anchored in Self-Determination Theory and Gender Role Theory investigates the differential impact of tailored, school-based physical activity programs Aerobic Plus Resistance Training (APRT), Functional Training Program (FTP), Plyometric Training Program (PTP) alongside Behavior Change Techniques (BCT), influence sports participation, physical fitness, and sedentary behaviour among inactive Pakistani schoolchildren aged 9–12. A cross-sectional survey combined with a pre–post intervention design was conducted within the School Education Department (SED Punjab), with gender examined as a moderating factor. Ethical approval was obtained from the University Malaya Research Ethics Committee and the SED Punjab. The research involved 90 children who were physically inactive and unwilling to participate in sports activities, and these children were randomly divided into three groups (APRT = 30, PTP = 30, FTP = 30). The EUROFIT instrument was used to assess physical fitness, while YAP was used to assess sedentary behavior, and PAQ-C was used to assess sports participation. The data analysis was conducted using SPSS and included Pearson correlations, regression models, and ANCOVA with a significance level of $\alpha = 0.05$. The results showed that all interventions were effective, but functional and plyometric training were more effective in improving movement quality and reducing sedentary time. Gender was a significant moderator in several relationships, with boys benefiting more from the interventions. These results highlight the need for developing school-based physical activity programs that incorporate behavioral strategies and are gender sensitive. The functional and plyometric approaches were found to be effective in both genders. Encouraging team sports within the school day may be a practical and effective strategy for helping children meet the World Health Organization recommendations for daily physical activity.

Index Terms— BCT, APRT, PTP, FTP, Gender, Sports participation, Physical fitness, Sedentary behaviour

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Introduction

The World Health Organisation (WHO) has recently indicated that physical inactivity is more common and severe among boys and girls (Xu et al., 2022), and it has been identified as the fourth largest cause of death globally (Shanshan et al., 2025). In order to guarantee that the WHO's recommendations for daily physical activity are embraced and met by student populations, schools should encourage physical activities like sports and exercise Zheng et al. (2025). All ages should be encouraged to lead healthy lifestyles, although habits are more likely to stick if they are established early (Iranpour et al., 2025). One of the best strategies to avoid dying young is to engage in

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regular physical activity. At least 150 minutes of moderate physical exercise, 75 minutes of strenuous activity, or a mix of the two should be done each week, according to Deng et al. (2024). Numerous sectors have investigated how gender affects employee attitudes (Pinto et al., 2023). Some have argued that gender differences continue to be a potentially significant antecedent as seen by the strength of relationships, despite recent research suggesting that there are no discernible differences between the sexes (Soto-Lagos et al., 2022; Xu et al., 2022) Sedentary Behaviour (SB) should be evaluated regardless of physical activity level because it is linked to higher cardiovascular risk factors and morbidity (Pinto et al., 2023). The WHO wants to see a 15% global decrease in the prevalence of physical inactivity by 2030 (H. Chen et al., 2022). According to Telford et al. (2021), about 25% of the general population satisfies the global requirements for physical inactivity, with men outperforming women by more than 8%. Specifically, women were found to have the greatest rate of inadequate physical inactivity among children worldwide (43.7%), with a 9.4 percentage point difference between males and females (Stockwell et al., 2021). The research conducted by Schlund et al. (2021), across different countries supports the observed gender differences.

The WHO Global Action Plan for Physical fitness aims to decrease physical inactivity among children and adolescents by 15% by 2030 (Soto-Lagos et al., 2022). Mendonça et al. (2022) recommend that stakeholders should collaborate to establish programs that enhance physical fitness opportunities for children of all abilities before and after school hours. The research shows that after-school physical activities improve fitness levels and body composition while reducing adiposity in school-age children and suggests these programs play a crucial role in children's physical fitness development (Basterfield et al., 2022). Consequently, schoolchildren's general health may be improved, and the prevalence of physical inactivity may be reduced with the help of after-school physical activities.

One popular technique for physical conditioning is plyometric exercise. It has been demonstrated to significantly enhance adolescents' 8–11 jumping abilities (Zheng et al., 2025). This effectiveness results from the plyometric training's efficient use of both mechanical and neurophysiological models. According to Iranpour et al. (2025), elastic potential energy is enhanced and stored when a muscle is stretched quickly. The accumulated elastic potential energy is promptly released when the stretched muscle is quickly contracted in a concentric contraction, boosting the force production of the muscle (L. Chen et al., 2023). The muscle in the neurophysiological model increases the force of the concentric contraction by applying the stretch reflex principles (Deng et al., 2024). However, a variety of factors may influence how effective plyometric exercise is for teenagers.

Functional training is a promising approach that is becoming more and more popular in clinical practice, based on the idea that enhancing functional capacity should be the primary goal of physical training programs for the aged 9 to 12. In order to promote multisystem adaptations and ensure autonomy when performing daily functions, it is based on the application of multi-segmental exercises carried out at maximum concentric speed (Lima et al., 2021). Its goal is the integrated development of physical valences (muscle strength and power, dynamic balance, motor coordination, agility, flexibility, and cardiovascular capacity) in movement patterns frequently used in daily activities (Liao et al., 2022).

Research indicates that although anaerobic exercise stimulates anabolic pathways, aerobic exercise activates catabolic pathways , It's commonly accepted that aerobic endurance training has little impact on muscle growth. Zheng et al. (2025) and Sadiq et al. (2024) suggests that gaining 4.5 pounds of muscle mass would result in a daily rise of roughly 50 kcal in resting metabolic rate. As a result, during physical exercise, muscular tissue requires more energy when there is increased muscle mass. Furthermore, increasing caloric expenditure with aerobic endurance training contributes to the reduction of body fat (Mendonça et al., 2022). It has been determined that incorporating aerobic endurance exercise within a weight-management program is crucial to attaining the best possible health-related results (Lima et al., 2021; Pires et al., 2020).

Motivational theories have been used by behavioural scientists and psychologists to pinpoint the mechanisms and modifiable elements associated with health behaviours. The research findings provide essential information for developing behavioral interventions (Rizal et al., 2025; Teixeira et al., 2020). Self-determination theory stands as a well-established motivational theory that demonstrates its effectiveness in understanding psychological factors that drive motivated behavior across different health domains. Research shows that theory-based interventions successfully promote both motivation and actual participation in health behaviors among different population groups and across various settings and behaviors. Research on self-determination theory-based intervention techniques remains limited despite previous studies that defined and detailed educational interventions based on this theory (Ruiz-Montero et al., 2020).

Theoretical Framework and Research Model

Self-determination theory and gender role theory

The motivational framework of self-determination theory shows successful predictions of motivated actions across various health behaviors, such as smoking cessation and physical activity and dietary habits, as well as different settings and populations. Self-determination theory ranks as one of the top motivation theories because it focuses on motivation quality instead of quantity. People's actions receive priority from the self-determination theory, together with their motivation levels. The theory requires researchers to distinguish between self-determined (autonomous) motivation and non-self-determined (controlled) motivation (Prince et al., 2020; Teixeira et al., 2020).

These motivational subtypes demonstrate the degree of support that individuals give to their own behavior. Autonomous motivation emerges when people endorse their own reasons for performing specific actions to achieve particular objectives. People who behave for autonomous reasons believe that they are the source of their activities and perceive them as freely chosen and in line with their true sense of self, values, and personal objectives (Ouyang et al., 2020).

Gender role theory, Franke et al. (1997), provides a theoretical framework for studying how boys and girls perceive their work activities differently. According to gender role theory, boys and girls value work differently from family activities because of traditional gender stereotypes (Moreno-Crespo & Pérez-Pérez, 2014). People's behaviors, roles, and attitudes according to gender role theory (Franke et al., 1997) are primarily shaped by societal expectations rather than biological factors. The theory explains how learned messages from peers and family members, media, and cultural institutions determine what is considered masculine or feminine, thus creating specific expectations that affect opportunities and choices (Eagly & Sczesny, 2019; Wu & Wu, 2019). The study of Gender Role Theory enables researchers to understand why boys and girls respond differently to Aerobic Plus Resistance Training (APRT), Functional Training Program (FTP), Plyometric Training Program (PTP), and Behaviour Change Techniques (BCT) in the physical training interventions discussed. Gender stereotypes about physical abilities and appropriate sports and body images may influence children's motivation to participate in sports activities. It is crucial to study how these deeply ingrained social roles affect inactive children's ability to become active (Lago-Ballesteros et al., 2021; Ruiz-Montero et al., 2020). The model demonstrates how physical activity outcomes in schoolchildren are affected by BCT, APRT, FTP, and PTP, with gender acting as a moderating factor. The model examines three physical fitness results, including physical fitness, sports participation, and sedentary behavior.

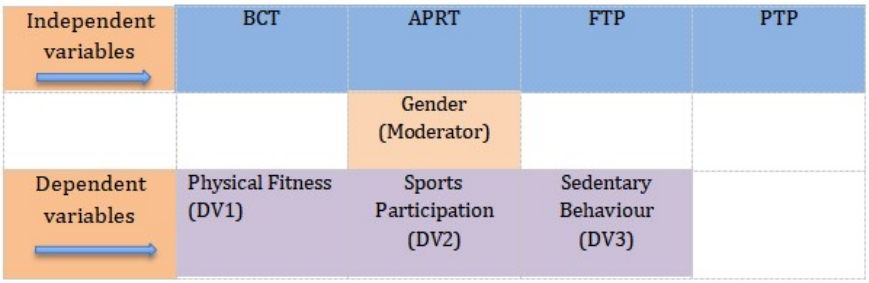

Fig. 1 *Research framework*

Hypothesis Development

BCT impact on physical fitness, sports participation, and sedentary behaviour

The focus of several Behaviour Change Strategies (BCTs) could be on post-intentional processes. The study focuses on three main topics, which include action planning, coping planning, and self-monitoring (Zheng et al., 2025). These methods are well-established and crucial to closing the intention-behavior gap in the HAPA model (Basterfield et al., 2022). The approach is general and adaptable, making it simple to apply to a variety of activities, including sedentary behaviour (Stockwell et al., 2021), sunscreen use (Ağdemir et al., 2025; Rhodes et al., 2021), and eating behaviour. Our daily actions have a significant impact on our health. The Country Health Rankings state that healthy habits like diet, physical inactivity, alcohol consumption, and smoking can explain 30% of health differences. Teixeira et al. (2020) advise engaging in moderate-to-intense physical activity at least once a week. According to Romero-Blanco et al. (2020), vigorous intensity physical activity is defined as having a Metabolic Equivalent of Task (MET) value of ≥6 MET, whereas moderate-intensity physical inactivity is any activity with a MET value between 3 and 5. The phrase "Sedentary Behaviour" (SB) was used more recently to refer to any activity that involves sitting or reclining and an energy expenditure of 1.5 MET or less (Meyer et al., 2020). The majority of the time, BCTs are employed in conjunction with numerous other approaches in complex interventions. It's yet unknown how effective individual BCTs or certain BCT combos are. The literature contains hints that some BCTs are superior to others. Alomari et al. (2020) found in their meta-analysis that programs involving "self-monitoring" in conjunction with at least one additional approach were more successful in promoting physical activity and good eating than those that did not. However, due to the non-experimental character of the design, which precludes cause-effect inferences, definitive findings are not yet feasible. Experimental studies examining the effectiveness of individual BCTs with physical fitness, sports participation, and sedentary behaviour are required. There are very few of these research (Dempsey, Matthews, et al., 2020; Lesinski et al., 2020). Additionally, knowledge of the effectiveness of individual BCTs can help direct the creation of new interventions. Interventions may be more effective if only effective BCTs are used (Ouyang et al., 2020; Rachman & Hendrawan, 2021). Given that e- and m-health programs frequently have significant attrition rates (60–80%), this is crucial (Prince et al., 2020). Interventions

involving a large number of BTCs may become increasingly complex, time-consuming, and uninteresting (Meyer et al., 2020; Rosenkranz et al., 2020). It may be possible to lessen participant burden and attrition rates by incorporating only efficient strategies.

H1: There is a significant relationship between BCT with physical fitness, sports participation, and sedentary behaviour.

APRT impact on physical fitness, sports participation, and sedentary behaviour

The human metabolic rate increases when muscles become hypertrophied (Pires et al., 2020). The metabolic rate of muscle tissue ranges between 10 and 15 kcal/kg, which translates to 4.5 and 7.0 kcal/lbs (Lee et al., 2024). The study of physical inactivity and strength training interventions spanning 8–52 weeks demonstrated a muscle mass increase of 2.2–4.5 kilograms (Katsamba, 2025; Tan et al., 2023). According to Haider et al. (2019) and Mendonça et al. (2022), a 4.5-pound increase in muscle mass would lead to a daily increase of approximately 50 kcal in resting metabolic rate. The increased muscle mass requires additional energy consumption from muscular tissue during physical exercise. The combination of aerobic endurance training with increased caloric expenditure helps people lose body fat (Lima et al., 2021; Suprapto, 2022). The most effective health-related outcomes from weight-loss programs require the addition of aerobic endurance training, according to Teixeira et al. (2020). Concurrent strength and aerobic training is a crucial component of physical training meant to enhance both athletic performance and overall health (Pires et al., 2020). Researchers examined the effects of integrating training modalities in one intervention program on fitness in addition to the health advantages (Mendonça et al., 2022). Lesinski et al. (2020), enhancing power by integrating two strength training modalities into a single intervention program, demonstrated the effectiveness of complex training and its superiority over traditional resistance training in attempts to increase the strength component in light of fitness-related outcomes in Pakistani weightlifters with at least two years of state-level competitive weightlifting experience (Saeterbakken et al., 2022). It's commonly accepted that aerobic endurance training has little impact on muscle growth. Research indicates that although anaerobic exercise stimulates anabolic pathways, aerobic exercise activates catabolic pathways (Mendonça et al., 2022). When paired with strength training, some recent studies Teixeira et al. (2020) showed no influence from aerobic training. According to Tan et al. (2023), concurrent training can be a useful tactic to increase lower-body maximum strength and total lean mass in a manner comparable to resistance-only training without taking into account muscle hypertrophy, independent of the order of the exercises. According to the same study, traditional resistance training might make concurrent training easier for building strength. Additionally, no hypertrophic factors were used in this investigation. On the other hand, a sedentary lifestyle is speeding up the ageing process and becoming a major issue for contemporary civilizat(Lee et al., 2024). Poor cardiorespiratory function and an increased risk of chronic illnesses have been linked to insufficient physical exercise (Pires et al., 2020). Additionally, a sedentary lifestyle can harm mental health, impede cognitive function, lower metabolism, result in obesity, and deteriorate muscles (Lima et al., 2021). Most children lead inactive lives. Maintaining physical inactivity is therefore essential, particularly for children. Therefore,

H2: There is significant relationship between APRT with physical fitness, sports participation and sedentary behaviour.

FTP impact on physical fitness, sports participation, and sedentary behaviour

Originating in the fields of physical therapy and rehabilitation, functional training is an evidence-based exercise technique that has recently been included in athletic training programs to improve sports participation (Liao et al., 2022). The goal of FTP for young people is to maximise the body's functional integrity as a whole movement system. One tool for analysing movement characteristics and identifying strengths and deficiencies is the functional movement screen (Lima et al., 2021). Developing safe and long-lasting teenage fitness regimens may be made easier with an understanding of the quality of specific movements. According to Van Roie et al. (2020), FTP training significantly increased the functional movement quality and physical fitness of girls aged 9 to 12. Nevertheless, there is little evidence of the FTP intervention's comparative impact on teenagers of both sexes throughout a larger age range, such as middle school and high school pupils. Children and young people benefit greatly from physical activity, and according to national guidelines, school-aged children should engage in 60 minutes of moderate-to-vigorous physical activities promote in school students. Less than 25% of Pakistani adolescents between the ages of 9 and 12 fulfil that physical exercise recommendation, though. Adding to this issue, studies reveal that rates of adherence to physical activity guidelines sharply decline as people move from childhood to adolescence. These patterns pose serious public health issues, and there is an urgent need for practical methods to encourage children and young people to be more physically inactive (Van Roie et al., 2020). A program that offers children and youth a structured series of practices and competitions is known as youth sport. Sport participation is a subset of physical activity (Fühner et al., 2021). Youth sport program participants are more likely than their peers who do not participate in sports to be physically active, burn more energy, and spend more time in other activities, according to Chia et al. (2022) and Lesinski et al. (2020). In a similar vein, kids who participate in structured school sports programs are more active. However, research also indicates that when kids grow older and enter adolescence, they frequently discontinue participation in sports activities. There are several reasons why people quit doing sports, such as a lack of enjoyment, time restraints, or possibilities to participate (Saeterbakken et al., 2022). According to Eather et al. (2023) and Farley et al. (2020), kids who take part in sports programs

in middle school and continue to do so throughout high school should continue to be more physically active than kids who don't. Hence,

H3: There is significant relationship between FTP with physical fitness, sports participation and sedentary behaviour.

PTP impact on physical fitness, sports participation, and sedentary behaviour

From the perspective of physical demands, it has been shown that sprint speed, leaping, and change of direction speed are important factors that determine single-leg hops performance (Zheng et al., 2025). A popular and effective training technique, plyometric exercise can cause physiological changes linked to the force-velocity connection, muscle pennation angle, and muscle fiber-type transition (Palma-Muñoz et al., 2021; Shah et al., 2024). Youth athletes may see gains in the previously indicated physical fitness characteristics as a result. Coaches should take into account a number of elements in order to develop safe, effective, and efficient physical therapy programs (Ramirez-Campillo et al., 2020). These include the training surface, the strength of the leaps (i.e., drop height), and the type of jump exercise (i.e., vertical vs. horizontal) (Deng et al., 2024). Furthermore, it appears that the training volume, that is, the quantity of jumps which can be progressively raised over time, is also quite significant. However, the research has not sufficiently addressed the safety and efficacy of volume-based overload in a sport like basketball, where there is a comparatively high load of jumps. Despite the fact that there have been a number of prior PTP studies on young single-leg hop players, the impact of volume-based overload during the intervention has not been examined in these studies (L. Chen et al., 2023; Palma-Muñoz et al., 2021; Ramirez-Campillo et al., 2021). In addition to components of physical fitness, variables relating to body composition are of crucial importance to Butt Kicks players (Ruiz-Montero et al., 2020). For instance, players may be able to perform better in specific positions (guard, for instance) if their body fat percentage is lower, whereas players may be able to advance to a higher playing level (professional from amateur) if they are taller (Lesinski et al., 2020).

Furthermore, it appears that improvements in body composition factors like decreased body fat and larger muscle fibers have a beneficial impact on sprint and jump performance (Farley et al., 2020; Westerbeek & Eime, 2021). As a result, PTP can have positive impacts on factors related to body composition, including decreased fat mass, improved muscle growth, and enhanced bone mass (Fühner et al., 2021). Muscle mass, muscle force, and power generation gradually decrease as people age. Compared to maximal force or muscle mass, this reduction is more noticeable in power and fast force output (Ramirez-Campillo et al., 2021; Saeterbakken et al., 2022). Furthermore, people who can produce a lot of force are better equipped to execute daily tasks like getting out of a chair and climbing stairs (Chia et al., 2022). Muscle force must be produced quickly in reactive motor activities, such as balance recovery after abrupt disturbances (Basterfield et al., 2022; Ojaghlou et al., 2025). Exercise regimens for children should therefore focus on reducing lower-limb power and delaying force output, as both have been suggested as significant indicators of age-related decline in functional performance.

H4: There is a significant relationship between PTP and physical fitness, sports participation, and sedentary behaviour.

The moderating role of gender

For boys and girls of all ages, physical activities like physical fitness, sports participation, and sedentary behaviour offer a host of health advantages (Kaewdok et al., 2018; Xu et al., 2022). For kids and teenagers, schools are the most significant educational setting (Selvarajan et al., 2015). In most parts of the world, they are in a good position to reach kids and teens of all ages and socioeconomic backgrounds. Additionally, schools have a significant role to play in encouraging involvement in physical activities. In addition to physical education classes, active breaks between classrooms, playtime, and after-school programs can also be used to promote PA during the school day (Eagly & Sczesny, 2019). Different nations have different rules and recommendations regarding PA requirements and school promotion (Lago-Ballesteros et al., 2021; Ruiz-Montero et al., 2020). Children and adolescents who are physically inactive may experience negative social, physical, and cognitive health outcomes as well as mental and physical illnesses (Soto-Lagos et al., 2022). Since PA behaviour is carried over from childhood and adolescence into adulthood, physical inactivity in young individuals frequently becomes a lifetime issue (Shanshan et al., 2025). Therefore, it's critical to start urging kids to lead more active lives at a young age. However, children and adolescents are more likely than boys to be physically inactive, and this prevalence is significantly higher among females. Boys tend to be more active than females both during playtime periods (Rhodes et al., 2021; Soto-Lagos et al., 2022) and generally (Schlund et al., 2021). A portion of the daily PA should be completed during school hours because most children and teenagers spend a lot of time there. Sadly, this rarely occurs, even though opportunities for PA are frequently provided in a number of regular school activities (such as physical education, playtime, and after-school programs) (Westerbeek & Eime, 2021). Despite the fact that there are differences in PA between boys and girls, the causes of these variances are varied and not entirely understood. Research on gender and health has a long history of conceptualizing health behaviours (including physical fitness, sports participation, and sedentary behaviour) as both products of and influenced by societal gender constructions (Kaur et al., 2020; Melby et al., 2023; Owen et al., 2020; Saunders et al., 2020; Shull et al., 2020; Xu et al., 2022). One gender may have a more skewed and wider range of activity if this difference arises from volitional activity, such as sports or physical play, with a bigger subset of that gender engaging in such activities (Ouyang et al., 2020). It's possible that there is less of a difference between boys and girls in light-intensity activities, or those that make up "everyday" activities, with little variation. One of

the biggest public health issues facing many nations is the rising rate of physical inactivity among children, adolescents, and adults (Liao et al., 2022). Sport is a kind of recreational physical activity that is typically competitive, structured, and organised. It can be performed individually in some situations, but it is typically played in teams. Sport's position in society has grown in importance for promoting public health as understanding of the health advantages of physical activity has grown (Lima et al., 2021). The value of sports in accomplishing public health objectives has been recognised by numerous countries worldwide (Shull et al., 2020).

Although club sports are thought to be more advantageous than informal group or individual sports, "informal" participation in sports is growing quickly in comparison to formal and traditionally organised club-based sports participation. This has created new opportunities for sports participation in recent years (Chia et al., 2022; Fühner et al., 2021; Telford et al., 2021). The physical demands of club sports are primarily responsible for their positive physiological effects (Eather et al., 2023; Saeterbakken et al., 2022). A review of the gender relationship on BCT, APRT, FTP, and PTP with physical fitness, sports engagement, and sedentary behaviour is presented in this study in recognition of the importance of the effects of these factors.

H5: There is a significant moderating role of gender relationship on BCT with (a) physical fitness, (b) sports participation, and (c) sedentary behaviour.

H6: There is a significant moderating role of gender relationship on APRT with (a) physical fitness, (b) sports participation, and (c) sedentary behaviour.

H7: There is a significant moderating role of gender relationship on FTP with (a) physical fitness, (b) sports participation, and (c) sedentary behaviour.

H8: There is a significant moderating role of gender relationship on PTP with (a) physical fitness, (b) sports participation, and (c) sedentary behaviour.

Method

Study design

The pre-test post-test experimental research design was used to assess the effects of Aerobic Plus Resistance Training (APRT), Functional Training Program (FTP), and Plyometric Training Program (PTP) on several key outcomes related to inactive school children.

Instruments

The EUROFIT test battery measured physical fitness through an adopted scale, which Ruiz et al. (2011) reported had a reliability of (α = 0.93). The YAP scale measured inactive school children's sedentary behavior with a reported reliability of (α = 0.77) according to Segura-Díaz et al. (2021), and the sports participation PAQ-C adopted with its reported reliability (α = 0.82) by Valenciano-Valcárcel et al. (2025).

Ethical considerations

Before data collection, this research has been approved by the University Malaya Research Ethics Committee (UM.TNC2/UMREC_3831) and the School Education Department (SED. Memo No.227/G.B).

Participant

School children who are inactive and not interested in taking part in sports activities from the School Education Department (SED Punjab). The total number of participants for each set of exercise is 30 (APRT =30, PTP = 30, and FTP=30). Total participant =90

Inclusion and exclusion criteria

Inactive School Children aged between 9 and 12 years. Inclusion and Exclusion Criteria are the same for the whole study.

Table I
Demographic information of the participants

Sr. No	Contrasts	Mean	*SD*	*f*	%
	Gender Wise Information				
1	**FTP**(*n*=30)	3.60	1.81		
	Boys			16	53.3
	Girls			14	46.7
2	**APRT**(*n*=30)	1.40	0.49		
	Boys			18	60.0
	Girls			12	40.0
3	**PTP**(*n*=30)	1.57	0.50		
	Boys			13	43.3
	Girls			17	56.7

The table below presents descriptive statistics of Aerobic Plus Resistance Training (APRT), Functional Training Program (FTP), and Plyometric Training Program (PTP) intervention exercises, for each of the four different exercises performed by a group of 30 participants. Looking at the Functional Training Program exercise, push-ups had the highest mean of 3.40, with a standard deviation of 1.070, including a moderate level of variability in the number of push-ups completed. Lungs had the lowest mean, 1.63, and the smallest deviation, 0.809; crab walks had a 3.23 mean and a 1.194 standard deviation, and lastly, jumping jacks had a mean of 2.00 and a standard deviation of 1.259. In the Aerobic plus resistance training program, wall push-ups had the highest mean, 3.47, and standard deviation, 0.776; running had the lowest mean, 1.87, and standard deviation, 1.197; sit-ups had a 3.27 mean and 1.311 standard deviation; and lastly, squats had a 2.30 mean and 1.368 standard deviation. Finally, the plyometric training program exercises, wall jump rope, had the highest mean of 4.20 and standard deviation of 0.805, Broad Jumps had the lowest mean of 1.10 and standard deviation of 0.305, single-leg hops had 3.53 mean and 0.571 standard deviation, and lastly Butt Kicks had 3.07 mean and 0.809 standard deviation.

Table II
Descriptive analysis of PTP, FTP, and APRT intervention's exercises

Sr. No	Intervention Exercises	*n*	Mean	Std. Deviation
	FTP			
1	Push-Ups	30	3.40	1.070
2	Lunges	30	1.63	.809
3	Crab Walks	30	3.23	1.194
4	Jumping Jacks	30	2.00	1.259
	APRT			
5	Wall Push-Ups	30	3.47	.776
6	Sit-Ups	30	3.27	1.311
7	Squats	30	2.30	1.368
8	Running	30	1.87	1.196
	PTP			
9	Jump Rope	30	4.20	.805
10	Single-Leg Hops	30	3.53	.571
11	Broad Jumps	30	1.10	.305
12	Butt Kicks	30	3.97	.809

Results

This research's parameters all had Confirmatory Factor Analysis (CFA) results using (Hair et al., 2024), which validated the suggested measurement model. The means, standard deviations, and correlations of the variables are shown in Table I, and the type and intensity of variable relationships are assessed using the Pearson correlation test, which is then used to determine whether the relationships are substantial, positive, or negative. Pearson's correlation indicates that there is a linear relationship between the variables (Hair et al., 2024). If the correlation value is 0, there is no correlation; if it is one or two, there are both positive and negative correlations. Table 1 shows a strong and favourable association between the variables. The results of a two-tailed test are shown in Table III, which also indicates whether the association is positive or negative and significant at the 0.01 level.

Table III
Means, standard deviations, and intercorrelations among variables

	1	2	3	4	5	6	7
BCT (90, 4.24, 3.287)	1						
APRT (90, 3.25, 3.347)	0.675**	1					
FTP (90, 5.42, 3.433)	0.487**	-0.543**	1				
PTP (90, 4.76, 4.543)	0.478**	-0.698**	0.586**	1			
PF (90, 4.34, 3.567)	0.654**	0.645**	-0.644**	0.665**	1		
SP (90, 5.87, 3.235)	0.597**	-0.587**	0.765**	0.776**	0.654**	1	
SB (90, 5.08, 3.532)	0.476**	-0.634**	0.871**	0.526**	0.564**	0.987**	1

The connection between BCT and sedentary behaviour, sports participation, and physical fitness was examined using regression analysis. The findings indicate a significant correlation between BCT and sedentary behaviour (β = 4.286; p=0.01), sports participation (β = 4.165; p=0.03), and physical fitness (β = 5.432; p=0.01). The findings indicate a connection between Aerobic Plus Resistance Training (APRT) and sedentary behaviour, sports participation, and physical fitness. The findings indicate a significant correlation between Aerobic Plus Resistance Training (APRT) and sedentary behaviour (β = 4.964; p = 0.00), participation in sports (β = 7.986; p = 0.01), and physical fitness (β = 6.987; p = 0.00). The findings indicate a correlation between Functional Training Program (FTP) and sedentary behaviour, sports participation, and physical fitness. The findings indicate a significant correlation between Functional Training Program (FTP) and sedentary behaviour (β = 7.312; p = 0.02), sports activity (β = 11.852; p = 0.00), and physical fitness (β = 0.851; p = 0.05). The findings indicate a connection between the Plyometric Training Program (PTP) and sedentary lifestyle, sports participation, and physical fitness. The findings indicate a significant correlation between Plyometric Training Program (PTP) and sedentary behaviour (β = 0.867; p = 0.07), participation in sports (β = 8.741; p = 0.01), and physical fitness (β = 4.329; p = 0.01).

Table IV
ANCOVA results

Variable	F-Statistics for the Dependent Variables		
	Physical Fitness	Sports Participation	Sedentary Behaviour
BCT	5.432	4.165	4.286
APRT	6.987	7.986	4.964
FTP	0.851	11.852	7.312
PTP	4.329	8.741	0.867

To better comprehend the interaction results, Figs. 2, 3, and 4 display the gender as a moderator for both high and low levels of BCT. Boys showed significantly higher levels of BCT in relation to sedentary behaviour (β = 4.487; p = 0.02), participation in sports (β = 6.397; p = 0.01), and physical fitness (β = 5.287; p = 0.01) than did girls.

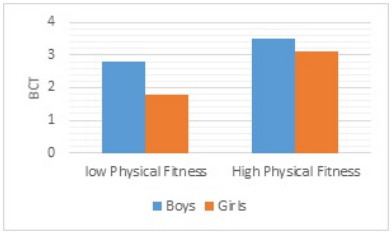

Fig. 2 *Gender moderates BCT and sedentary behaviour*

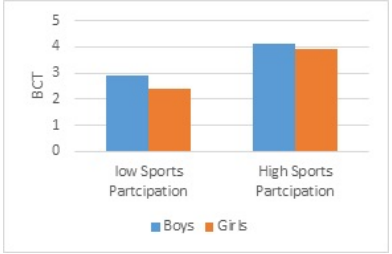

Fig. 3 *Gender moderates BCT and sports participation*

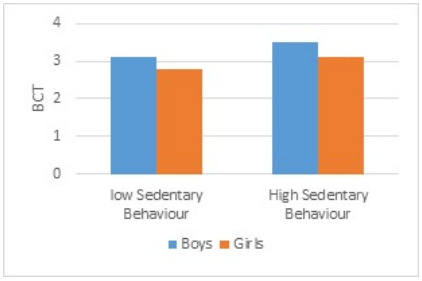

Fig. 4 *Gender moderates BCT and sedentary behaviour*

To better comprehend the interaction results, Figs. 5, 6, and 7 display the gender as a moderator for both high and low levels of APRT. The APRT levels for physical fitness (β = 0.198; p = 0.09), participation in sports (β = 11.464; p = 0.01), and sedentary behaviour (β = 2.357; p = 0.03) were substantially higher in boys than in girls. 6a is therefore not supported. Statistical analysis supports this moderation effect (β = 2.357; p = 0.03), confirming Hypothesis 6c. While Hypothesis 6a was not supported (p = 0.09), Hypotheses 6b and 6c are supported, indicating that APRT is more effective in reducing sedentary time and promoting sports participation among boys.

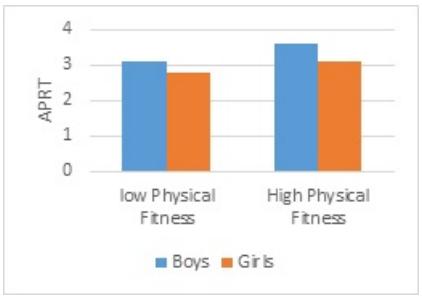

Fig. 5 *Gender moderates APRT and physical fitness*

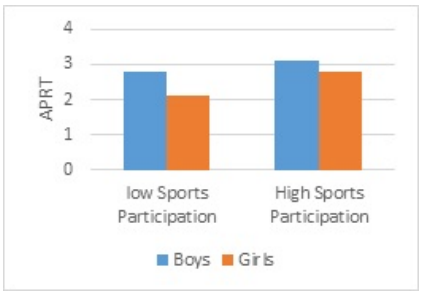

Fig. 6 *Gender moderates APRT and sports participation*

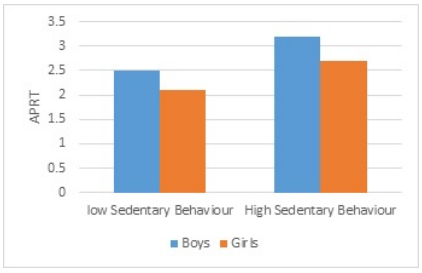

Fig. 7 *Gender moderates APRT and sedentary behaviour*

Figs. 8, 9, and 10 show the gender as a moderator for both high and low levels of FTP to help understand the interaction results. Boys had significantly higher FTP levels than females for physical fitness (β = 5.754; p = 0.00), participation in sports (β = 0.542; p = 0.05),

and sedentary behaviour (β = 3.654; p = 0.02). Statistical analysis supports the moderating role of gender in all three sub-dimensions, confirming Hypotheses 7a,7b, and 7c.

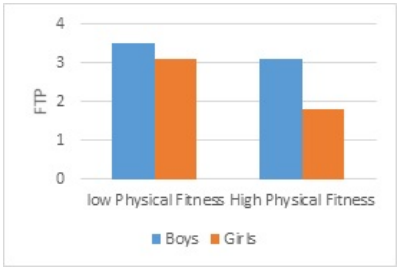

Fig. 8 *Gender moderates FTP and physical fitness*

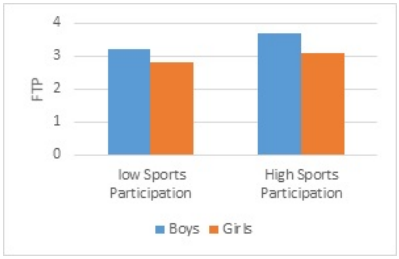

Fig. 9 *Gender moderates FTP and sports participation*

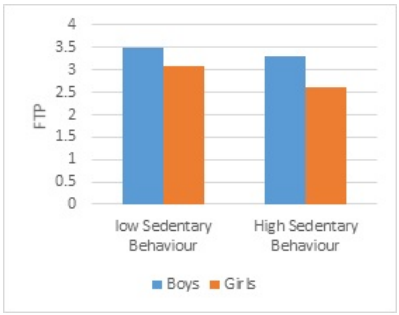

Fig. 10 *Gender moderates FTP and sedentary behaviour*

To further comprehend the interaction results, Figs. 11, 12, and 13 display gender as a moderator for both high and low levels of PTP. PTP levels for physical fitness (β = 0.097; p = 0.12), participation in sports (β = 8.539; p = 0.00), and sedentary behaviour (β = 5.286; p = 0.01) were substantially higher in boys than in girls. While Hypothesis 8a is not supported due to non-significant results (p = 0.12), Hypotheses 8b and 8c are supported, indicating that PTP is more effective in enhancing sports participation and reducing sedentary behaviour among boys.

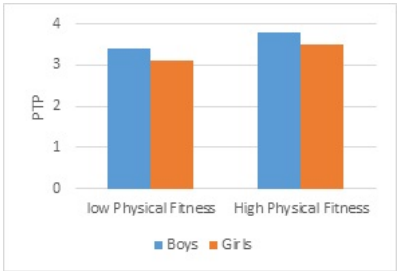

Fig. 11 *Gender moderates PTP and physical fitness*

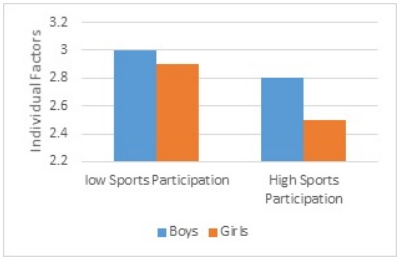

Fig. 12 *: Gender moderates PTP and sports participation*

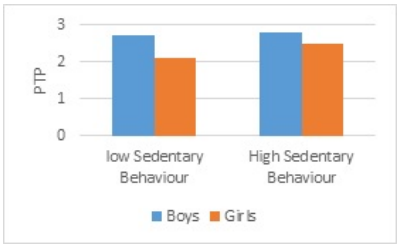

Fig. 13 *Gender moderates PTP and sedentary behaviour*

Discussion

This study investigates the associations between BCT, APRT, PTP, and FTP and sedentary behaviour, sports participation, and physical fitness. Our findings reveal significant insights into how these interventions can "unlock activity" in inactive children, with particular attention to reducing sedentary behaviour and addressing gender-specific responses.

The result collectively indicates that all four interventions (BCT, PTP, APRT, and FTP) contribute positively to addressing inactivity in children, with varying strengths across different aspects of physical activity. The robust relationship observed, particularly for APRT and FTP across multiple outcomes, highlights their potential as effective strategies for promoting a more active lifestyle, reducing sedentary behaviour, and enhancing overall physical well-being in inactive children. The slightly weaker, but significant, connection of PTP with sedentary behaviour warrants further exploration, but its strong connection to sports participation and physical fitness warrants further exploration.

The result indicates that the moderating effect of gender on the relationship between BCT and outcomes related to physical activity, with boys demonstrating significantly higher levels of engagement and benefits from BCT across multiple domains compared with girls. The result shows that BCTs are generally effective; their impacts are not uniform across gender, with boys appearing to be more responsive to these interventions in promoting physical activities. This disparity could be attributed to various factors, rooted in gender role theory, where societal expectations might align more closely with the competitive and often emphasized emphasis in physical activity interventions, which may resonate with boys. Previous studies consistently reported that boys are, on average, more physically active than girls, particularly in moderate physical activity, a trend observed across various age groups Alomari et al. (2020) and Dempsey, Biddle, et al. (2020). Gender role theory posits that societal norms reinforce traditional gender stereotypes, associating physical powers, competitiveness, and sports with masculinity. Consequently, boys may be more intrinsically motivated by competitive aspects often embedded in physical activity programs and BCT, which align with these societal expectations (Kaur et al., 2020). In order to ensure equitable and optimal results in promoting physical activity among all inactive children, it is imperative that future interventions be more gender-sensitive. This could be achieved, for example, by implementing BCTs that emphasise social support, enjoyment, and skill mastery for girls, while utilising competitive and performance-based strategies for boys.

The finding shows that gender is a moderator, with boys demonstrating subsequently higher benefits across physical fitness, sports participation, and sedentary behaviour compared to girls.

Prior research consistently indicates that boys, on average, exhibit higher levels of physical activity, especially in organised sports and activities requiring strength and power, compared to girls (Lee et al., 2024; Melby et al., 2023). A core outcome of this study was to understand whether and how the intervention led to a reduction in sedentary behaviour. Our findings suggest that engagement in sports, fostered by increased physical fitness and participation, plays a critical role in mitigating sedentary behaviour. The positive energy balance and the ensuing weight gain and fat deposition have also been linked to physical inactivity. Fortunately, consistent physical activity participation can lessen these detrimental effects. The metabolic system, particularly glucose homeostasis and decreased insulin

sensitivity, may also be impacted by decreased APRT and increased SB. Reduced cardiac and vascular functions, as well as muscular oxidative capacity, have also been linked to impaired cardiovascular endurance. Regarding cardiorespiratory capacity, it appears that the metabolic properties of high-intensity interval exercises, in conjunction with the central circuits found in the FT set, can enhance aerobic performance by bringing about central adaptations and peripheral adaptations, which alter the mechanisms of oxygen transport and utilisation, leading to changes in the mechanisms of oxygen transport and utilisation, including an increase in the oxidative capacity of the muscle cell, an increase in the breakdown of glycogen and phosphate, and an improved use of intramuscular triglycerides (Mendonça et al., 2022; Stockwell et al., 2021).

The analysis of FTP also revealed that a significant moderating effect of gender in physical fitness, sports participation, and sedentary behaviour was observed between girls and boys of inactive children in schools. Studies show that boys generally demonstrate higher levels of overall physical activity and participation in sports, which can be partly attributed to societal gender roles that traditionally encourage competitiveness and physical powers in boys (Lima et al., 2021; Van Roie et al., 2020). While FTP can benefit both boys and girls, its demanding nature and focus on challenging complex movements might be more appealing as more attainable by boys who often possess higher baseline levels of strength and motor skill proficiency due to greater prior physical activity engagement (Liao et al., 2022). In terms of dynamic balance and agility, for example, both genders responded favorably to the PTP and FTP therapies; nevertheless, additional research may show whether one gender improved more noticeably in specific fitness domains. For instance, prior studies have occasionally shown that, in response to comparable training stimuli, boys and girls build their strength or adjust their cardiorespiratory systems differently. A more thorough analysis of gender-specific responses should help guide tailored interventions, even though the current study validates the programs' overall beneficial effects.

The analysis of PTP also revealed that a significant moderating effect of gender in physical fitness, sports participation, and sedentary behaviour was observed compared between girls and boys of inactive children in schools. Plyometric training, characterized by explosive high-impact movements, often aligns with activities where boys typically demonstrate greater natural advantage in power output and explosive strength due to physiological factors such as muscle fiber distribution and hormonal profile. Furthermore, societal gender roles, as explained by gender role theory, often encourage boys to participate in sports that emphasize strength, speed, and completion, making them more adaptable to the demands of plyometric training. On the other hand, girls might be less interested in or confident in high-impact, power-focused activities. This could be because they don't think they're competent, they're afraid of getting hurt, or they're just accustomed to less violent sports (PubMed Central, 2021). The marginal significance for girls' physical fitness indicates that although PTP can be helpful, its effects might not be as noticeable as they are for boys, especially if girls aren't using the intensity or technique necessary for the best adaptations.

In relation to sports engagement and its association with sedentary behaviour, we discovered that children who participated, both girls and boys, maintained higher levels of physical activity and demonstrated less sedentary behaviour than their counterparts who did not participate. This implies that sports have a generally beneficial impact on lowering sedentary time for both males and females. Boys and girls both showed gains in a number of physical fitness metrics. Our findings, however, imply that particular interventions may have slightly varied effects. In order to maximise gender-sensitive physical activity solutions for children who are not active, future research should specifically examine whether boys or girls respond better to specific exercise modalities or program formats.

Practical and theoretical implications

The study provides crucial practical insights for addressing the global health concern of physical inactivity among school children, particularly in the Pakistani context. The findings strongly advocate for integration of tailored, school-based activity programs, especially APRT, PTP, FTP, and BCT. The demonstrated effectiveness of all interventions, with FTP and PTP showing superior effects in improving movement quality and reducing sedentary time, suggests that these programs are viable, impactful strategies for increasing physical activities, enhancing physical fitness, and curbing sedentary behavior in inactive children aged 9-12. The research highlights the need for gender sensitive program design. Given that boys benefited more prominently form the interventions and policymakers should adapt these programs to address the unique motivational factors and preferences faced by inactive girls. This might involve different types of activities and motivational strategies to ensure equitable outcomes. Furthermore, the recommendation to encourage team sports within the school day is a practical and impactful strategy, and recommendations for daily physical activity by leveraging the inherent social and competitive aspects that often motivate children. The research significantly contributes to self-determination theory and gender role theory by empirically demonstrating their relevance in understanding physical activity interventions. The overall effectiveness of the physical activity programs and BCT supports self-determination theory by suggesting that providing children with competence, autonomy, and relatedness through structured physical activity can intrinsically motivate them towards greater engagement. The study's use of gender role theory as a critical lens for analysing the varying effects of interventions, however, is its most notable theoretical contribution. The consistent finding was that gender moderated the impact of the interventions, with boys benefiting more prominently. The theory shows that societal gender norms and expectations influence physical activity patterns in interventions. Therefore, gender should be explicitly

included as a crucial moderating component in future theoretical models of physical activity promotion, examining the ways in which psychological drivers of behaviour and socially imposed gender roles interact to affect the results of physical activity. More complicated theoretical frameworks that more fully explain the intricate interactions between social context, individual psychology, and the efficacy of interventions in encouraging children to engage in physical exercise over the long term may result from this nuanced knowledge.

Limitations and future research

The study's comprehensive planning and execution require acknowledgment of specific limitations that affect the generalizability of the research results.

One primary limitation is the comparatively small sample size. The study would have benefited from a larger participant number to enhance its ability to predict results for various population groups. The study design, as a cross-sectional study, presents another limitation. This design provides a snapshot of associations but cannot establish causality. Future research should consider a longitudinal approach to track changes in sedentary behaviour, physical activity, and fitness in children. Thirdly, although the study concentrated on children aged 9 to 12, assessing the effects of these interventions over a wider age range throughout childhood and adolescence may show age-specific efficacy. Last but not least, in order to help children fulfil WHO recommendations, future research might examine the best ways to integrate physical activity into the curriculum and evaluate the viability and effects of promoting particular team sports. This would involve examining the consequences for school policy, resource allocation, and teacher training.

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