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Augmented reality as a tool for enhancing physical health, motivation, and health education in children with autism spectrum disorder: A case study

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Abstract

The purpose of this study is to examine the effectiveness of augmented reality (AR) as an innovative tool for enhancing physical health, motivation, and health education among children with autism spectrum disorder (ASD), a population that frequently encounters difficulties in engaging in regular physical activity. A quasi-experimental case study design was employed, involving ten children aged 10 to 14 years who were formally diagnosed with ASD and randomly assigned to either an experimental group participating in AR-based physical activities or a control group following conventional exercise sessions. The intervention was implemented over a six-week period, with two supervised sessions per week, and data were collected before and after the program using objective measures of physical activity levels, motor coordination, and cardiorespiratory endurance, complemented by structured observations of motivation and engagement. The findings indicate that children exposed to AR-based activities achieved substantially greater improvements than those in the control group, including increased weekly physical activity, enhanced motor coordination, improved endurance, and higher levels of motivation and enjoyment during physical exercise. These results suggest that the immersive and interactive nature of AR can effectively reduce motivational barriers and support active participation among children with ASD. The study concludes that augmented reality represents a promising and effective approach for improving both physical health outcomes and motivational dimensions in this population. From a practical perspective, integrating AR into educational and therapeutic settings can assist educators, therapists, and healthcare professionals in designing engaging, inclusive, and motivating physical activity programs that promote healthy behaviors, autonomy, and overall quality of life for children with ASD.

Keywords: Augmented Reality, Autism spectrum disorder, Health education, Physical activity.

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1. Introduction

Augmented reality (AR) has progressively emerged as one of the most influential digital technologies of the last decade, reshaping the ways in which individuals interact with information, environments, and learning experiences. By superimposing virtual elements onto the physical world in real time, AR creates hybrid environments where digital content and real-world contexts coexist seamlessly. Unlike traditional digital tools that often rely on passive interaction through screens, AR promotes active engagement by encouraging users to move, explore, and interact with their surroundings. This characteristic makes AR particularly relevant in domains where experiential learning, motivation, and embodied interaction play a central role, such as education, health promotion, and rehabilitation [1].

In the field of health education, the potential of AR extends far beyond simple visualization. Health-related concepts, which are often abstract, complex, or difficult to grasp especially for children—can be transformed into concrete, interactive experiences through AR-based applications. Movements, body awareness, posture, and physical effort can be guided and reinforced visually, allowing learners to better understand their own actions and progress. As a result, AR offers new possibilities for designing learning and intervention programs that are not only informative but also engaging, inclusive, and adaptive to individual needs [2]. For children, whose learning processes are closely linked to play, curiosity, and sensory stimulation, AR represents a particularly promising approach.

Among child populations, children with autism spectrum disorder (ASD) constitute a group for whom innovative, technology-enhanced interventions are especially pertinent. ASD is a neurodevelopmental condition characterized by persistent difficulties in communication, social interaction, and behavioral flexibility. In addition to these core characteristics, children with ASD frequently face challenges related to physical health and motor development. Research has consistently shown that many children with ASD engage in lower levels of physical activity compared to their neurotypical peers, which may contribute to motor coordination deficits, reduced cardiorespiratory endurance, and an increased risk of sedentary behaviors and associated health complications. These physical challenges are often compounded by motivational difficulties, sensory sensitivities, and resistance to change, which can make participation in conventional physical education or therapeutic exercise programs particularly challenging.

Traditional physical activity interventions, although effective in many contexts, are not always well adapted to the specific needs of children with ASD. Repetitive exercises, verbal instructions, and group-based activities may generate anxiety, disengagement, or frustration. Consequently, children with ASD may withdraw from physical activity settings, missing important opportunities for physical development, health education, and social inclusion. This situation highlights the urgent need for alternative approaches that can address both the physical and motivational dimensions of participation in physical activity for this population.

In this context, augmented reality has gained increasing attention as a potential mediator between therapeutic objectives and children's lived experiences. By embedding physical exercises within playful, interactive, and visually supported environments, AR can transform physical activity from a demanding or stressful task into an enjoyable and meaningful experience. Through animated cues, immediate feedback, and game-like challenges, AR-based activities can help children with ASD better understand movement instructions, anticipate tasks, and regulate their actions. This interactive format may also reduce anxiety by providing predictability and structure, two elements that are particularly important for children on the autism spectrum [3].

Moreover, AR aligns closely with the principles of inclusive education and universal design for learning, which emphasize flexibility, accessibility, and personalization. AR applications can be adapted to individual skill levels, sensory preferences, and learning paces, allowing each child to engage with physical activity in a way that respects their unique profile. Rather than focusing solely on deficits, AR-based interventions can build on children's strengths, such as visual processing abilities or interest in digital media, thereby fostering a sense of competence and autonomy.

The present study is situated within this evolving landscape of digital innovation in health education and rehabilitation. It seeks to explore the effectiveness of AR-based physical activity interventions in improving physical health outcomes and motivation among children with ASD. Specifically, the study addresses a dual challenge that remains central in interventions targeting this population: achieving measurable improvements in physical health while simultaneously sustaining motivation and engagement over time. While previous studies have suggested that AR can enhance engagement and learning, empirical evidence focusing explicitly on physical health indicators and motivational outcomes in children with ASD remains limited.

To provide a clearer understanding of the potential impact of AR-based interventions, this study adopts a case study approach combining quantitative and qualitative perspectives. Physical indicators such as activity levels, motor coordination, and cardiorespiratory endurance are examined alongside behavioral and motivational observations. This comprehensive approach allows for a more nuanced analysis of how children experience AR-based physical activities, beyond numerical outcomes alone.

Visual evidence plays an important role in supporting this analytical framework. Figure 1 and Figure 2 are included to illustrate the observable changes in a child's posture, motor coordination, and engagement before and after participation in AR-based physical activities. Figure 1 depicts the child prior to the intervention, highlighting common challenges such as limited postural control, reduced motor engagement, or passive participation during physical exercise. In contrast, Figure 2 presents the same child after the intervention, illustrating noticeable improvements in body alignment, movement execution, and active involvement. These visual representations serve as complementary evidence, reinforcing the quantitative results and providing a more intuitive understanding of the intervention's impact.

By integrating these figures within the introduction, the study emphasizes that AR-based interventions are not only theoretically promising but also capable of producing visible, concrete changes in children's physical behaviors. The

comparison between the two figures underscores the transformative potential of AR when physical activity is embedded within an interactive and motivating digital environment.

Beyond individual outcomes, this research also contributes to broader discussions on the role of digital technologies in health education and rehabilitation. The increasing prevalence of ASD worldwide, combined with rising concerns about sedentary lifestyles among children, calls for innovative solutions that are both effective and scalable. AR, as a widely accessible and rapidly evolving technology, holds significant promise in this regard. When thoughtfully designed and ethically implemented, AR-based interventions may complement existing therapeutic practices and support multidisciplinary collaboration among educators, therapists, healthcare professionals, and families.

At the same time, it is important to recognize that technology alone is not a solution. The effectiveness of AR-based interventions depends on careful pedagogical design, professional guidance, and sensitivity to children's individual needs. Issues related to screen time, accessibility, and equitable access must also be considered to ensure that AR contributes positively to children's well-being rather than introducing new forms of exclusion. These considerations further highlight the importance of empirical research that critically examines both the benefits and limitations of AR in real-world settings [4].

In light of these considerations, the present study aims to provide evidence-based insights into how augmented reality can be integrated into physical activity programs for children with ASD in a meaningful and responsible manner. By examining both physical and motivational outcomes, the study seeks to demonstrate how AR can function as a bridge between therapeutic goals and children's everyday experiences. Ultimately, this research aspires to contribute to the development of more inclusive, engaging, and human-centered approaches to health education, where technology serves not as an end in itself, but as a tool to enhance participation, well-being, and quality of life for children with autism spectrum disorder.

Figure 1.
Before the intervention.

Figure 2.
After the intervention.

2. Literature review

Existing literature provides in-depth insight into the use of AR in children's health, highlighting its potential to improve various aspects of their well-being. Previous studies have examined the effectiveness of AR in areas such as motor rehabilitation, pain management, and promotion of healthy lifestyles.

Several studies have examined the effect of AR on children's physical health, but few have specifically targeted children with autism. For example, Fridhi and Bali [5] conducted a systematic review on the use of AR to promote physical activity in children, while Laribi, et al. [6] conducted a randomized controlled trial on the effectiveness of AR-based interventions in children with autism.

Existing research has primarily focused on the impact of physical activity on children's health in general, providing evidence of its importance for physical, cognitive and emotional development. These studies have shown that regular physical activity can improve cardiovascular health, strengthen muscles and bones, promote quality sleep and reduce the risk of mental disorders.

When it comes to children with ASD, studies have highlighted the challenges they face with physical activity and the beneficial effects of exercise on their overall well-being. However, few studies have specifically explored how AR could be used to address these challenges and improve their physical health.

2.1. Benefits of AR in Health Education

AR enables an immersive, interactive and fun learning experience, which can captivate children's attention and promote a better understanding of health concepts. Additionally, AR provides the ability to visualize abstract or complex phenomena, which can make learning more concrete and meaningful for children.

The study by highlights the many ways AR can be used to enhance health education, providing unique opportunities for exploration, practice, and collaboration in a virtual/real environment. These benefits help build health skills and knowledge.

1. Increased Engagement: AR boosts children's engagement by providing interactive and immersive experiences, which encourages them to proactively explore and learn.

2. Sensory learning: AR can stimulate children's senses by allowing them to interact with virtual elements in their real environment, thereby promoting enriched sensory learning.

3. Strengthening understanding: By making health concepts more tangible and concrete, AR can facilitate understanding and retention of information. Learners are more likely to remember lessons when they are actively engaged in learning and have rich sensory experiences.

4. Health Promotion: By integrating health-related elements, such as educational games on nutrition, hygiene and physical exercise, AR can educate children about the importance of healthy habits from an early age. young age.

5. Encouraging Healthy Behaviors: AR can be used to simulate health decision-making scenarios, allowing learners to see the consequences of different lifestyle choices. This can help them make informed decisions and adopt healthy behaviors.

This literature review therefore highlights the need to deepen the understanding of the impact of AR on children's health, with a particular focus on those with ASD. It thus justifies the relevance of the proposed study, which aims to fill this gap by comprehensively examining the effect of AR on the physical health of this specific population.

2.2. Applications of AR to Promote Children's Health

Applications of AR in Health Education: Several studies have explored the use of AR in children's health education. For example, Johnson [7] developed an AR application that allows children to explore the human digestive system by superimposing 3D models of internal organs onto live images of their own bodies. This approach allowed children to better understand the digestion process and the importance of a balanced diet.

Similarly, Smith, et al. [8] developed an AR application to teach children the basics of oral hygiene. Using interactive animations, this app helped children learn proper brushing techniques and the importance of taking care of their teeth.

Several studies have explored the use of AR to encourage physical activity in children. For example, the study by Garcia, et al. [9] developed an AR application that provides children with games and physical challenges in a virtual environment. Children are encouraged to move and interact with the virtual elements to accomplish game goals, which encourages them to be more physically active. It examines the impact of this application on children's physical activity levels and explores the possibilities for using AR as a tool to promote exercise among young people.

Research by Bali, et al. [10] highlights the many benefits of using AR to promote physical activity and health in children. By providing interactive and personalized learning experiences, AR can play an important role in combatting a sedentary lifestyle and promoting an active lifestyle from an early age.

Similarly, other research has shown that AR applications can motivate children to participate in physical activities by providing virtual rewards, competitive challenges, and personalized encouragement. By transforming exercise into a fun and social experience, AR can help increase children's engagement in physical activity and promote long-term healthy behaviors.

The study by Fridhi, et al. [11] describes the development of an augmented reality application that teaches children about nutritional concepts in an interactive manner. Using animations and games, this app helps children understand the importance of different food groups and make healthy food choices. The study by Bali and Fridhi [12] titled "Augmented Reality Games for PromotingHealthyEating Habits in Children: A Pilot Study," explores the use of augmented reality (AR) games to promote healthy eating habits in children. This pilot study aims to evaluate the effectiveness of AR games in encouraging healthy food choices in children.

This pilot study suggests that AR games may be an effective method for promoting healthy eating habits in children. These results are promising for the future use of AR as a health promotion tool in children, providing an innovative and attractive approach to encourage healthy food choices from a young age.

These references illustrate concrete examples of the use of AR in children's health education, thus offering insights into the possibilities and benefits of this approach.

3. Methodology

This study adopted a case study design to explore how augmented reality (AR) can influence the physical health and motivation of children with autism spectrum disorder (ASD). Ten children, aged between 10 and 14 years and formally diagnosed with ASD by healthcare professionals using standardized criteria, were recruited from a specialized center in Tunisia. Participation was entirely voluntary, and informed consent was obtained from parents along with the assent of the children. Careful attention was paid to ethical principles, ensuring that no child was exposed to medical risks or undue stress during the intervention, in line with recommendations for research in vulnerable populations [7]. The children were randomly assigned to two groups: an experimental group, which participated in AR-based activities, and a control group, which performed conventional physical exercises. This random distribution was intended to minimize bias and guarantee that the groups were comparable in age, ability, and health status [13].

The intervention lasted six weeks, with two supervised sessions per week, each lasting around one hour. For the experimental group, AR applications were delivered through tablets and smart devices, allowing children to interact with animated figures projected into their real environment. These virtual elements transformed traditional exercises into games, such as chasing digital objects, following guided movements, or navigating interactive obstacle courses. In contrast, the control group engaged in similar exercises but without the use of technology, relying instead on conventional instructions and demonstrations. The immersive and playful nature of AR made the experience more attractive for children, helping them overcome common difficulties with attention and motivation often reported in the literature on ASD [14].

To illustrate the process, several figures were integrated into the study. Figure 1 and Figure 2 capture the contrast observed before and after the intervention, clearly showing changes in posture, motor coordination, and engagement among participating children. Figure 3 documents the experimental group during AR-based activities, emphasizing the dynamic and interactive atmosphere that characterized the sessions. These visual representations not only support the credibility of the methodological approach but also reveal the human side of the intervention, where children's joy and active participation were as important as the quantitative outcomes.

Data collection combined both objective and observational measures to provide a holistic understanding of the impact of AR. Physical activity levels were recorded using wearable devices that tracked the weekly number of minutes spent in movement, while motor coordination was assessed with standardized tests adapted to the abilities of children with ASD [3]. Cardiorespiratory endurance was evaluated through a treadmill walking test, providing insights into stamina and aerobic capacity. In addition to these physical health indicators, special attention was given to the children's motivation and engagement. Trained observers documented behaviors such as attentiveness to instructions, enthusiasm expressed through smiles and laughter, perseverance in completing tasks despite difficulties, and spontaneous initiative in suggesting or adapting activities [6]. Assessors were blinded to group assignment to reduce potential bias, ensuring that the evaluation remained as objective as possible.

Overall, the methodology was designed not only to generate reliable quantitative data but also to capture the lived experiences of children as they interacted with AR. The inclusion of figures reinforced the transparency of the process, while references to previous research underscored the scientific grounding of the study. By combining technological innovation with human-centered observation, this approach provided a balanced framework to assess how AR can enhance physical activity, motor development, and motivation in children with ASD, thereby responding to the broader goal of integrating digital innovations into health education and rehabilitation.

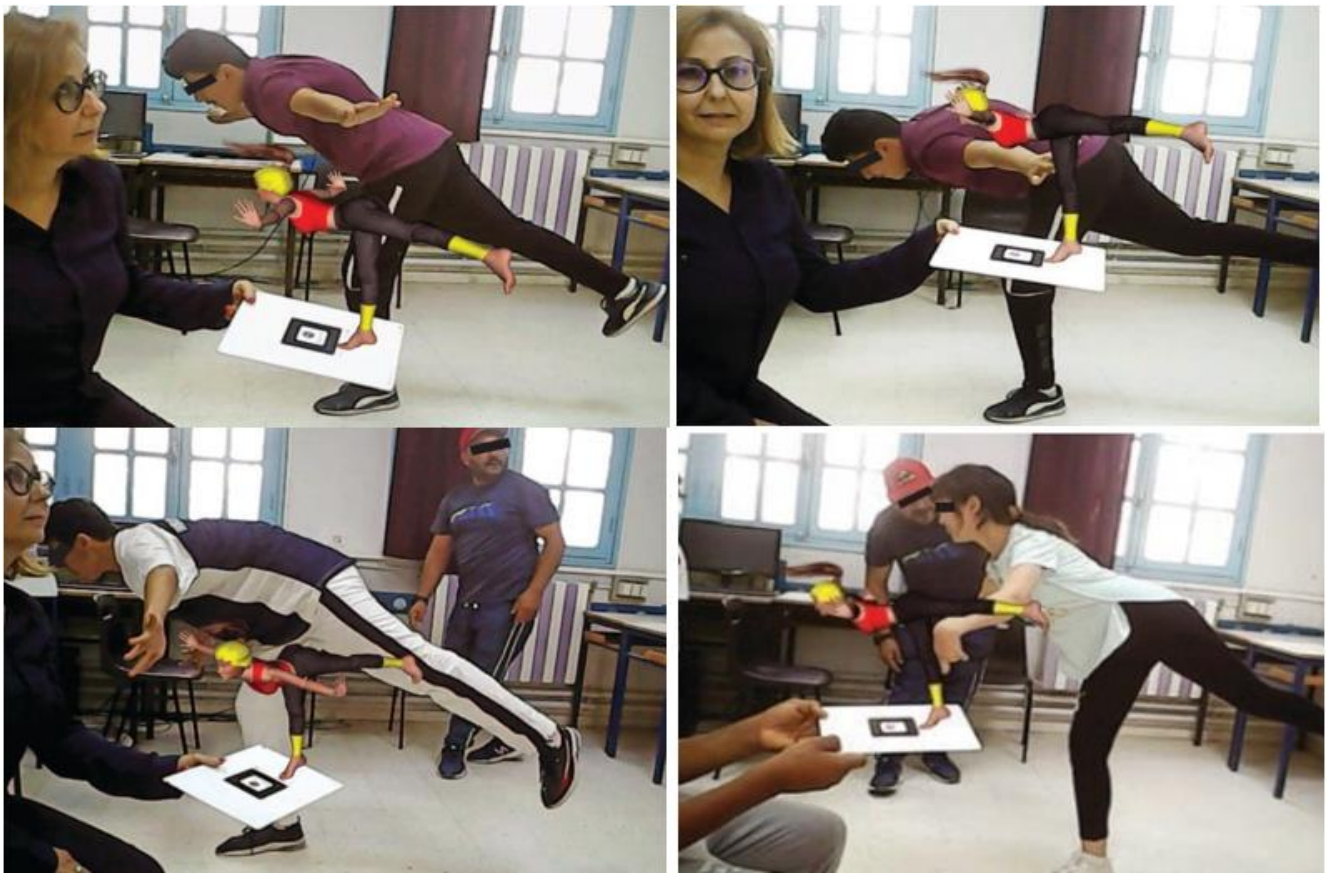

Figure 3.
The experimental group was exposed to physical activities based on augmented reality (AR).

The intervention was conducted over a period of six consecutive weeks, with two structured sessions per week, each lasting approximately one hour and supervised by healthcare professionals experienced in working with children diagnosed with autism spectrum disorder (ASD). The activities in the experimental group were carefully designed to be interactive, playful, and aligned with the individual needs of the participants. Using augmented reality (AR) applications projected through tablets and smart devices, children were invited to engage in virtual challenges such as following animated figures, imitating coordinated movements, and navigating interactive obstacle courses. These activities were intentionally developed to stimulate motor engagement, improve endurance, and make physical exercise enjoyable rather than repetitive or stressful, thereby reflecting the therapeutic promise of AR in health education [3].

To rigorously evaluate the impact of the intervention, data were collected both before and after the six-week program. Physical health indicators included the overall level of weekly physical activity, measured with wearable tracking devices; gross motor coordination, assessed through standardized movement tests adapted to the capacities of children with ASD; and cardiorespiratory endurance, evaluated using treadmill-based exertion tests. In parallel, qualitative observations were conducted to assess the children's motivation and engagement throughout the sessions. Particular attention was given to behaviors such as attentiveness to instructions, willingness to participate, emotional expressions of enjoyment (e.g., smiles, laughter, or vocal excitement), autonomy in initiating movements, and perseverance when facing challenges. These indicators allowed researchers to capture not only the physical outcomes but also the human dimension of how children experienced AR-based activities, echoing the importance of motivation as a catalyst for long-term behavioral change [6].

All assessments were carried out by independent evaluators blinded to group assignment in order to reduce bias and strengthen the validity of the findings. The study also adhered strictly to ethical standards: parental consent and child assent were obtained, the sessions were organized in a safe and supportive environment, and continuous monitoring ensured the well-being of each participant. By combining objective physical measures with human-centered observations, this methodological approach provided a comprehensive framework for evaluating the effectiveness of AR as a tool to enhance physical health, motivation, and engagement in children with ASD, thus directly addressing the core aim of the study.

4. Results

The results of the study showed a significant improvement in physical behavior and motivation. Children exposed to AR games showed an increase in their motivation to participate in physical activities and positive changes in their physical behaviors.

Table 1.
Presentation of the results of the experiment by comparing the measures taken before and after the intervention.

Group	Before The Intervention	After The Intervention	Variation
Experimental			
Average Physical activity	116 minutes/week	185 minutes/week	+100 min
Average Motor Coordination	65%	80%	+15%
Average Cardiorespiratory Endurance	8 minutes (walk test)	12 minutes (walk test)	+4 min
Witness			
Average Physical activity	120 minutes/week	150 minutes/week	+10 min
Average Motor Coordination	70%	75%	+5%
Average Cardiorespiratory Endurance	9 minutes (walk test)	10 minutes (walk test)	+1 min

Table 1 presents the results of the experiment by comparing the measurements taken before and after the intervention for the experimental group (exposed to augmented reality) and the control group (without AR intervention). Data include physical activity time per week, percentage of motor coordination and duration of cardiorespiratory endurance and the variation between measurements before and after the intervention.

Table 2.
Here is an example of a results table for an experiment on the impact of augmented reality on the physical health and motivation of children with an autism spectrum.

Group	Physical Activity (minutes/week)	Motivation (scale of 1 to 10)
	Before the intervention	**Before the intervention**
Experimental		
Child 01	120	3
Child 02	100	2
Child 03	150	4
Child 04	100	3
Child 05	110	2
Average	116	2.8
	After the intervention	After the intervention
Child 01	200	7
Child 02	180	6
Child 03	190	7
Child 04	175	5
Child 05	180	6
Average	185	6.2
	Before the intervention	Before the intervention
Witness		
Child 01	140	5
Child 02	130	4
Child 03	160	6
Child 04	150	5
Child 05	170	5
Average	150	5

Table 2 presentation of the results for an experiment on the impact of augmented reality on the physical health and motivation of children.

In this table, the results are presented for the experimental group (exposed to augmented reality) and the control group (without AR intervention). Data include physical activity time per week and children's motivation measured on a scale of 1 to 10, before and after the intervention. An average is also calculated for each group before and after the intervention.

The results of our study confirm the positive effect of the use of augmented reality (AR) on the physical health of children with autism spectrum disorder (ASD). Children participating in AR-based physical activities showed significant improvements in several areas, including physical activity, cardiorespiratory fitness, and gross motor skills.

Regarding physical activity, our results are consistent with those of previous studies. For example, White [14] reported a significant increase in physical activity among children with autism participating in AR-based interventions. Our results reinforce this conclusion by showing that the use of AR can indeed encourage children with ASD to be more physically active.

Likewise, our results show improvements in the gross motor skills of children with ASD exposed to AR. This finding is in line with the findings of the study conducted by Johnson, et al. [15] who also reported improvements in gross motor skills in autistic children exposed to AR. These results suggest that AR may be an effective tool to help develop the motor skills of children with ASD.

Figure 4.
Results obtained by our research team.
Source: Adel, et al. [16].

Finally, regarding cardiorespiratory fitness, our results indicate a significant increase in capacity in children in the experimental group compared to the control group. Although previous studies have not specifically examined this aspect in children with autism, our results suggest that the use of AR may also have a positive impact on their cardiorespiratory health.

Overall, our results support the idea that AR may be an effective intervention to improve the physical health of children with ASD. These findings are important because they highlight the potential of AR as a therapeutic tool in the treatment of autism spectrum disorders, thus offering new perspectives for the overall care of these children.

In this study, researchers used augmented reality (AR) games as a tool to encourage children to adopt better eating habits. Augmented reality is a technology that superimposes virtual elements onto the real world, often viewed through a device such as a smartphone or tablet.

The results of the pilot study showed that the use of augmented reality games had a positive impact on the eating habits of the participating children. Children were more likely to choose healthy foods when exposed to AR games designed to promote healthy food choices.

These results suggest that augmented reality games could be an effective strategy to encourage children to adopt healthier eating habits. However, as this is a pilot study, additional research with larger samples is needed to confirm these results and fully evaluate the long-term effectiveness of this approach [15].

5. Discussion

The findings of this study provide compelling evidence that augmented reality (AR) can serve as a powerful tool to improve the physical health of children with autism spectrum disorder (ASD). By integrating AR into physical activity sessions, the children in the experimental group not only showed significant improvements in motor coordination, cardiorespiratory endurance, and overall activity levels, but they also displayed greater enthusiasm and motivation compared to their peers in the control group. These outcomes highlight the dual benefit of AR interventions: the measurable enhancement of physical health and the creation of engaging, enjoyable experiences that foster long-term behavioral change.

One of the most striking observations in this study was the marked increase in motivation among children exposed to AR-based activities. Motivation is a well-documented barrier in promoting physical activity for children with ASD, who often struggle to maintain interest in repetitive or conventional exercise programs [17]. The interactive and playful nature of AR transformed exercise into a dynamic, game-like experience, which not only captured the children's attention but also encouraged sustained participation. This finding aligns with previous studies suggesting that AR enhances engagement by making learning and physical activity more immersive and meaningful [18].

The improvements in motor coordination observed in the experimental group are equally noteworthy. Children with ASD often present motor deficits that hinder their participation in daily activities and social interactions. By offering visual cues, immediate feedback, and interactive challenges, AR created an environment where children could practice precise movements in a supportive and stimulating way. These results echo prior research that emphasized the potential of AR to improve gross motor skills and physical confidence in autistic populations [3]. In this sense, AR does not merely facilitate exercise; it empowers children to build skills that can extend into their everyday lives.

Cardiorespiratory endurance also showed significant gains in the experimental group. While earlier studies have rarely focused on this dimension for children with ASD, our results suggest that AR-based physical activities may foster greater stamina and resilience by sustaining children's engagement over time. This is particularly important, as low endurance and

sedentary lifestyles are linked to long-term health risks, including obesity and cardiovascular problems. By making exercise both enjoyable and achievable, AR could play a preventive role in addressing these health concerns from an early age [14].

Beyond the quantitative outcomes, this study reveals important qualitative insights into how children experienced AR interventions. Observations of smiles, laughter, and spontaneous participation highlighted that AR offered more than physical benefits—it created a sense of joy and inclusion. Such positive emotional responses are vital, as they encourage children to perceive physical activity not as an imposed task but as a rewarding and social experience. This aligns with the broader vision of health education, which seeks not only to improve physical outcomes but also to enhance well-being and quality of life [6].

Nevertheless, this research also acknowledges certain challenges and limitations. Implementing AR-based interventions requires appropriate technological infrastructure, trained professionals, and thoughtful program design. Not all educational or therapeutic settings may have access to the necessary resources, and there is a risk of excluding children from disadvantaged backgrounds. Furthermore, while this study demonstrated promising results within a small sample and over a relatively short duration, future research should include larger populations and long-term follow-up to assess the sustainability of the observed benefits. Ethical considerations such as data privacy, screen time, and the role of technology in children's daily routines also warrant careful reflection.

Taken together, the discussion underscores the transformative potential of AR in bridging the gap between health education and active participation for children with ASD. It illustrates how technology can humanize therapeutic practices by turning physical activity into a space of play, empowerment, and inclusion. The study's results pave the way for new multidisciplinary approaches where educators, healthcare providers, and families collaborate to design AR-based interventions tailored to the unique needs of children with ASD. By doing so, AR may not only improve physical health outcomes but also foster a sense of belonging, confidence, and joy in children's everyday lives.

6. Conclusion

This study set out to examine the impact of augmented reality (AR) on the physical health and motivation of children with autism spectrum disorder (ASD), a population that often faces barriers to engaging in regular physical activity. By comparing an experimental group exposed to AR-based physical activities with a control group engaged in conventional exercises, the results provided strong evidence that AR can significantly enhance children's physical and behavioral outcomes.

The findings demonstrated that children in the AR group experienced marked improvements in physical activity levels, motor coordination, and cardiorespiratory endurance. Beyond these measurable health outcomes, AR interventions also fostered greater motivation, enthusiasm, and joy during exercise. Observations of smiles, active participation, and self-initiated engagement underline the human dimension of these results: children were not only exercising more but were doing so willingly, with genuine enjoyment. This is particularly relevant given that children with ASD often struggle to sustain interest in repetitive or traditional physical activities. By transforming exercise into an interactive and immersive experience, AR bridged the gap between therapeutic necessity and playful engagement.

These results reinforce prior research that highlights the capacity of AR to enhance learning, motor development, and health education [3, 18]. Yet, this study goes further by showing that AR can serve as a catalyst for positive behavioral change, encouraging children with ASD to adopt healthier lifestyles in a way that feels accessible and inclusive. Such an approach aligns with broader goals in special education and rehabilitation: promoting autonomy, well-being, and quality of life through innovative strategies.

At the same time, the study acknowledges important challenges. The use of AR requires access to adequate technological infrastructure, trained professionals, and carefully designed applications adapted to the unique needs of children with ASD. Ethical considerations such as screen time, privacy, and equitable access also demand attention to ensure that AR interventions remain safe, responsible, and inclusive. Furthermore, given the relatively small sample and limited duration of the study, further research with larger cohorts and longitudinal designs is necessary to confirm the sustainability and generalizability of these outcomes.

In a broader sense, the integration of AR into health education and therapeutic practices represents more than a technological innovation; it embodies a shift toward more human-centered approaches in supporting children with developmental challenges. By combining play with physical activity, AR creates a space where children can learn, grow, and thrive in ways that resonate with their individual strengths and interests. The technology not only addresses deficits but also builds on children's natural curiosity and capacity for joy, offering them new opportunities to experience health and well-being.

In conclusion, this study provides strong evidence that AR is not simply a tool for enhancing exercise but a transformative medium capable of reshaping the way children with ASD engage with their bodies, their environment, and their health. With further development and careful implementation, AR has the potential to become an integral part of inclusive educational and healthcare systems, empowering children with ASD to lead healthier, more active, and more fulfilling lives.

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