



## PAST & PRESENT, SCIENCE AND TECHNOLOGY IN PHYSICAL EDUCATION & SPORTS

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### ABSTRACT:

With time, science and technology have enormously been integrated in physical education and sports which have revolutionised training methodologies, performance analysis and prevention of injuries. Previously, physical education was mainly related to the traditional exercise and empirical knowledge, however, as of now, the advancements in biomechanics, sports physiology and data analytics have contributed to the transformation of the field. Wearable technology, motion tracking system, and artificial intelligence give the ability to precisely monitor performance of athletes, design the thousands of training programs more optimally, and prevent injuries. Additionally, sports medicine, nutrition science and psychological conditioning have made athletes better able to endure, and recover from, activity so we see better performance overall. In the current market, technology to revamp sports continues upon assisting physical education through virtual reality (VR) for training, real time feedback on biometrics and artificial intelligence (AI) driven coaching. Such developments enable customized training systems enabling results as per data driven information for the athletes. Moreover, the digital platforms and online fitness applications have made physical education more accessible, thus encouraging the practice of active lifestyles away from the traditional classroom. It also personalizes athlete development further by integrating genetic profiling to predict the potential of the athlete and his/her likelihoods of injury. The more we advance with science and technology, the better in terms of precision, inclusivity and performance optimization that physical education and sports will become in the future.

### KEYWORDS:

**SCIENCE, TECHNOLOGY, PHYSICAL EDUCATION, SPORTS PERFORMANCE, BIOMECHANICS, WEARABLE TECHNOLOGY, SPORTS MEDICINE, ARTIFICIAL INTELLIGENCE.**

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### INTRODUCTION

The science and technology role in physical education and sports has changed a lot over the years and how the athletes train, compete, and recover. The traditional exercises, the observational coaching methods and the general fitness principles were what physical education had relied upon in the past. For military and competitive purposes, the need for physical training was well known in ancient civilizations such as the Greeks and Romans, but human biomechanics and physiology were not understood scientifically until restricted by but a single arch. As such, scientific advances brought about methodologies for training in sports that shuffled in the principles of anatomy, physiology and kinesiology, within a program. Sports medicine and biomechanics grew in the 20th century, which allowed investigation in analyzing human movement, preventing injuries, and enhancing performance. Video analysis, computerized tracking systems and performance monitoring tools were introduced to experimentally monitor such aspects of sport implementation, and resulted in coaches and athletes being able to precisely analyze their techniques.

In this age, the technology has revolutionized physical

education and sports, providing athletes with data to optimize training and prevent injuries. Wearable tech like heart rate trackers and GPS trackers are great for tracking your workouts, as you can get real-time physiological data that can be used to create personalised fitness plans. Artificial intelligence and machine learning algorithms evaluate performance metrics and provide specific feedback to optimize training efficiency. Sports education of virtual reality and augmented reality has significantly changed, as it is possible to simulate real game situations and conduct training of tactical decision making. Additionally, digital platforms and fitness app have made training program more accessible and hence to lead an active lifestyle outside the traditional gym environ. Lifestyle profiling, genetic profiling and biomechanical assessments are used for talent identification and injury risk management. These technologies have not just improved athletic ability but they have also brought inclusivity within the realm of physical education and sports by allowing everyone irrespective of ability to participate. The role of science and technology in sports is likely to grow and get finer and finer with time as there



influential role in athletic training in the more modern days, and keeps getting more efficient, safer and inclusive.

## ANCIENT TRAINING TECHNIQUES AND PHILOSOPHIES

Training techniques had a deep influence by its cultural, philosophical and even military requirements. For instance, the Greeks placed great emphasis on physical training for the athletes and soldiers, particularly on endurance, strength and flexibility. These were games that included running, wrestling and discus throwing that had to be rigorously prepared for. In Greek gymnasiums, trainers, or paidotribes, helped young athletes prep for dread games by means of exercises carrying both physical and mental conditioning. In China, too, martial arts like Kung Fu were born, kind of combining martial training to spiritual and philosophical aspects such as Taoism and Confucianism. Other methods aimed to make changes in self-discipline, balance and agility.

India's regimen of training involved strength, flexibility and mental focus through yoga and wrestling. So, Pehlwani was a structured form of combat training, which consisted of strenuous strength building exercises, just structured diets. At the same time, the Romans adopted Greece training principles but instead of having more finesse they made it more to do with military readiness. Numerous exercises involving endurance drills, weight training and combat were performed by Roman soldiers so that they could always be at their maximum physical condition. Gladiators who spent their lives in arenas fighting each other for the public's amusement trained engaged in a specialized course of training that focused on both physical endurance, and combat skills. These early training techniques may not have been scientifically validated back then, but they showed a tremendous understanding of human physical potential and what would eventually become the sports science of tomorrow.

## AI AND MACHINE LEARNING IN TRAINING AND COACHING

Since then, artificial intelligence (AI) and machine learning has revolutionized the field of training and coaching making it data driven and ensuring better performance and a reduction in injury. These AI powered systems can post powerful analysis of data collected from wearable sensors, motion tracking devices, biometric monitors that can give an athlete real time feedback on his overall performance. These technologies allow coaches to evaluate movement efficiency, determine patterns, and offer suggestions on improvement very precisely. AI video analysis tools can break down an athlete's techniques frame by frame, and even break down the boring, painful stitching together of your best movements to reveal the inevitable inefficiencies and areas for improvement. Finally, machine learning algorithms enable the prediction of injury risks based on the analysis of training loads, fatigue levels, as well as biomechanics to facilitate timely action.

## Integrating AI Virtual Coach in Workplace Learning Ecosystem

- ◻ Personalized Learning Path
- ◻ Real-Time Feedback
- ◻ On-Demand Coaching
- ◻ Data-Driven Insights
- ◻ Lifelong Learning Culture



Personalized coaching is just a small part of the bigger AI picture apart from performance optimization. AI powered virtual coaching assistants provide the training programs based on individual athlete's skill level, personal strengths, weaknesses. It can provide real time corrective feedback through chatbots and AI driven applications to reduce the need of human supervision all the time. In a team sport field, AI is applied to explore the tactics, to determine each of their members' tactics, and to simulate possible game scenario. Additionally, AI integrated virtual reality (VR) training environment allows athletes to train on conditions that are real such as a real game, and in doing so, the decision making and reaction speed are improved. However, as AI and machine learning capability continues to further advance, the use of AI and machine learning for training and coaching will become increasingly prevalent for the sport scientist of the future, whereby training will become more efficient, more individualized and globally, more data driven.

## PERSONALIZED TRAINING AND REHABILITATION PROGRAMS

From modern sports science, a cornerstone concept has become the support of personalized training for improvement of athletes' performance due to individual needs, goals and physiological characteristics. Unlike traditional one size fits all workout programs, these personalized training programs rely on data analytics, wearable tech, and AI powered insights to customize the workouts and how to recover. By analyzing in factors such as muscle composition, endurance levels, and movement patterns, coaches and trainers develop customized regimens that are most efficient while producing the lowest possible risk of injury. Heart rate monitors and GPS trackers are worn devices that collect real time data about performance to make sure intensity of training does not exceed an athlete's capabilities.

Technological advancements have also work very well in the field of rehabilitation programs and have helped in providing better rehabilitation programs for injured athletes. Nowadays, physical therapists employ biomechanical assessments, motion capture systems, AI powered rehabilitation software to design the recovery plan. To train coordination and strengthen the body after

injuries, athletes use virtual reality (VR) rehabilitation programs that simulate real life motions. As well, electrical muscle stimulation and cryotherapy are used to expedite recovery. Integrating sports science, AI and medical knowledge ensures personalized training and rehabilitation programs get athletes safely and efficiently back to peak performances, minimizing the chances of re-injury. This procedure, not only helps elite athletes, but it also helps to prevent the injury and to stay fit and control weight level of persons at all level of fitness.

## LITERATURE REVIEW

**Antunes et al (2020)** A study of a sample of Portuguese adults during the COVID-19 pandemic was undertaken to establish the influence of lifestyle habits, physical activity, anxiety and basic psychological needs. These changes in lifestyle due to the pandemic caused forced disruptions in daily routines of the people with a reduction in the level of physical activities. Health concerns, social isolation, and future unknowns awoke anxiety levels. The basic psychological need of autonomy, competence, and relatedness were essential in preventing negative effects on mental health. Those who retained their regular level of physical activity had lower levels of anxiety and better psychological wellbeing. The results indicated interventions that would encourage healthy lifestyle habits, promote mental health and manage psychological needs of adults in the middle of such unprecedented times and in the context of ongoing uncertainty and social restrictions.

**Rhodes et al (2019)** Over the years, theories of physical activity behaviour change have emerged to include a range of psychological, social and environmental factors. Early models, like the Health Belief Model, were based on the premise that changing behaviour is a function of individual perceptions of the risks and benefits of desired health behaviour change. The Theory of Planned Behaviour included intention and perceived control as a component for physical activity and how these depend on attitudes, subjective norms and perceived behavioural control. The Social Cognitive Theory focused on the concepts of self-efficacy and observational learning, which indicates the effect of social influences on the behavior. Recent models such as the Trans theoretical Model, on the other hand, acknowledged that behaviour change is a multi staged process which occurs at stages and therefore interventions are specific to the readiness of an individual to change. The Ecological Model extended the focus to include environmental and societal factors and the presence of support systems and accessible spaces for physical activity. These theories, individually, collectively provide a complete picture of physical activity behaviour and help to inform effective interventions to foster lifetime exercise participation.

**Varea et al (2022)** The COVID 19 pandemic changed physical education dramatically, moving from a physical environment to virtual learning with a modification to how physical activities were taught and experienced. As schools closed and social distancing was enforced, physical

education instructors digitally came to the table to develop online classes, virtual fitness challenges and home exercise routines. Changes to these groups emphasized difficulties in maintaining student engagement and providing equal access to resources for physical activity, including those with limited space or equipment at home. Furthermore, physical education was no longer solely focused on physical fitness but encompassed additionally mental health and emotional wellbeing by enhancing focus on stress relief and coping strategies. As schools began to reopen, flexibility was being brought in through hybrid models that consisted of both in person and online elements. Despite the challenges that these shifts created, they enabled significant opportunities for innovation in delivery of physical education to be included and flexible within multiple delivery settings.

**Zamani Sani et al (2016)** There have been direct and indirect pathways presented between physical activity and self-esteem through psychological and physical mechanisms. Regular physical activity directly boosts self-esteem by improving physical fitness and body image and by enhancing health through many benefits. Often, these physical improvements result in higher confidence and a positive feeling about one's self. Physical activity can increase self-esteem indirectly by means of psychological mechanisms such as stress reduction, improved moods, and improved cognitive functions, which are viewed as positive aspects of living. However, group activities serve as a positive source of social interaction and the feeling of achievement from attaining fitness goals contributes to their role in improving self-worth. Also, regular physical activity can decrease the symptoms of anxiety and depression that can have a detrimental effect on self-esteem. In general, the relationship among physical activity, self-esteem, and self-worth is very complicated and involves both physical and psychosocial activity resulting in improved self-worth.

**Laranjo et al (2021)** Smartphone applications and activity trackers to increase physical activity in adults have become greatly popular tools by providing personalized tracking, goal setting, and feedback. These technologies allow users to be regularly engaged in exercise through real time data on steps taken, distance travelled and calories burned while a user can be able to monitor his or her progress. In addition, many apps and trackers offer reminder features or gamification through something like challenges or social features that can add that extra layer of motivation and accountability. Gamification elements, because rewards or virtual competitions are integrated, push engagement even further. Research shows that use of these devices can result in higher physical activity levels when the goal is targeted and they give continuous feedback. Moreover, some apps provide exercise plans made to fit the users, and enable users to find the virtual communities to support one's appetite growth. While these tools are effective, however, their effectiveness varies among people and for continued engagement, motivation is still needed.

**METHODOLOGY**

In this study, the method applied in the collection of data was through the administration of a survey to a sample of 100 respondents from the category of athletes, coaches, fitness enthusiasts, and physical education professionals. Convenience sampling was used to select the respondents in a manner that provides a diverse representation among individuals with a wide variety of physical education and sports experience.

Therefore, the survey aimed at evaluating the effect of technological advancements to various areas in physical education and sports. They were then asked to rate how their experiences and perceptions related on a number of key factors such as training techniques, injury prevention, performance monitoring, biomechanics analysis,

wearables technology, among others. These ratings are given on percentage scale, wherein the participants were allowed to rate their satisfaction, awareness, usage and effectiveness, before and after the introduction of technology. The data were then divided into two sections: Past (Before Technology) and Present (With Technology) so as to compare. Percentage Change was calculated on each factor in terms of the mean percentage score between the past and the present. The variability in the responses given by respondents was computed in terms of the standard deviations. By applying this approach, this technique yielded helpful quantitative data that tells us how technology has impacted physical education and sports history, using 100 sample people from two different eras.

**RESULTS AND DISCUSSION**

**IMPACT OF SCIENCE AND TECHNOLOGY ON PHYSICAL EDUCATION AND SPORTS**

Factor	Past (Before Technology)	Present (With Technology)	Change (%)
Training Techniques	35% satisfaction	85% satisfaction	+50%
Injury Prevention	25% awareness	80% awareness	+55%
Performance Monitoring	20% usage	75% usage	+55%
Biomechanics Analysis	10% usage	65% usage	+55%
Nutritional Science	15% usage	70% usage	+55%
Wearable Technology	5% usage	60% usage	+55%
Use of Virtual Reality in Training	0% usage	50% usage	+50%
Psychological Performance Support	30% usage	70% usage	+40%
Sports Analytics and Data Collection	10% usage	65% usage	+55%
Sports Equipment Innovations	25% effectiveness	80% effectiveness	+55%
Overall Impact on Performance	40% positive impact	90% positive impact	+50%

It can be seen in the table, that technological advances have an impact on many factors in physical education and in sports when looking from the past to the present (before/with technology). This signifies improvement in satisfaction, awareness, usage and effectiveness in different aspects such as demonstration rooms, online programs, publications, market visits as well as service calls. Satisfaction levels increase 50% for key factors such as training techniques and 55% for awareness of injury prevention. Performance monitoring and biomechanics analysis became more used (increase 55%) as showed the need of technology in order to track better and analyze

performance. The wearables technology and sports analytics also an increase of 55% in usage. Virtual reality and psychological performance support are also becoming much more common, and these technologies are helping to make training methods and mental support of athletes even better. Inventions of sports equipment and their significant effect on performance grew 55% and 50%, respectively. The data makes clear the impact of technology on the arena of physical education and sports, in which the performance, safety and modes of training have been very much improved overall.

**IMPACT OF SCIENCE AND TECHNOLOGY ON PHYSICAL EDUCATION AND SPORTS: BEFORE AND AFTER TECHNOLOGICAL INTEGRATION**

Factor	Past (Before Technology)	Present (With Technology)	Mean (%) Past	Mean (%) Present	Standard Deviation (Past)	Standard Deviation (Present)	Percentage Change
Training Techniques	35% satisfaction	85% satisfaction	34.5%	85.3%	10.2%	8.3%	+50.8%
Injury Prevention	25% awareness	80% awareness	24.9%	80.4%	7.5%	6.8%	+55.5%

Performance Monitoring	20% usage	75% usage	19.8%	74.9%	6.3%	7.1%	+55.1%
Biomechanics Analysis	10% usage	65% usage	9.8%	64.7%	5.4%	8.2%	+54.9%
Nutritional Science	15% usage	70% usage	14.7%	70.3%	6.1%	7.4%	+55.6%
Wearable Technology	5% usage	60% usage	5.1%	59.8%	3.5%	9.0%	+54.7%
Use of Virtual Reality in Training	0% usage	50% usage	0.0%	49.9%	0.0%	8.3%	+50.0%
Psychological Performance Support	30% usage	70% usage	29.6%	69.4%	8.9%	9.1%	+39.8%
Sports Analytics and Data Collection	10% usage	65% usage	9.7%	64.8%	4.8%	8.7%	+55.1%
Sports Equipment Innovations	25% effectiveness	80% effectiveness	24.5%	80.2%	7.2%	6.5%	+54.7%
Overall Impact on Performance	40% positive impact	90% positive impact	39.7%	90.1%	9.6%	7.4%	+50.4%

A comprehensive table of comparison of different factors in physical education and sports and how they got changed due to technological integration, named as "Impact of Science and Technology on Physical Education and Sports: Before and After Technological Integration" is submitted. The sample size was of 100 respondents and it investigates ten key factors, out of which included training techniques, injury prevention, performance monitoring, etc. The table contrasts the 'Past (Before Technology)' and the 'Present (With Technology)' scenarios of each factor, including percentage of past, present, satisfied, aware, used / works, etc. In addition, both Mean (%) Past and Mean (%) Present are in the table giving an average of how each factor was scored before and after integrating technology. Also, the Standard Deviation (Past and Present) is included to see the spread or variability in the data, i.e. how consistent or variable was for respondents' answer.

The Percentage Change column measures the change in respondent satisfaction, awareness or effectiveness from past to present, to show the effect of technology on each of these practices. The percentage change for each factor is usually positive as most of the factors reflected the substantial effect of technology which has been brought in the physical education and the sports. Satisfaction — 50.8%, prevention awareness — 55.5%, wearable tech — 54.7%, etc. To summarize, the table portrays how technology plays an essential part in enhancing physical education and sports. This demonstrates how wearable devices, performance monitoring, injury prevention and data collection tools have drastically enhanced the viability and use of training, which has become more personalized and practical. Based on the significant improvements on the stated areas it manifests that science and technology

have well impacted the world of physical education and sports in a positive way.

**CONCLUSION**

Science and technology has integrated to physical education and sports which has revolutionized the training methods, performance, monitoring, injury prevention, and all round the development of the athlete. Traditional techniques in the past were always oriented towards the employment of manual methods and scarce data, bringing to less personalized, and in many cases also, less effective, training regimens. However, technology has brought a change in how athletes and coaches train and compete through devices such as wearable devices, performance tracking software, biomechanics analysis, virtual reality, and so on. The response from the 100 person sample all showed significant improvement within all factors, with awareness of training techniques and injury prevention improving by as much as 55%. Sports analytics and biomechanical assessments have made available informative performances about an athlete and have led to more accurate interventions. Moreover, as wearable technology and virtual reality have become available, it has allowed for physiology data to be tracked real-time and virtual complex training scenarios to be simulated for increased skill development and decreased injury risks. In comparison, the percentage change in all factors represents the extremely positive role of technological advancements for physical education and sports. Moreover, shift to technology driven solution, has reduced time, efforts, and cost consumed, not only enhancing the efficiency and effectiveness of traditional methods, but also making training more accessible, personalized, and focused on improving long term athletic performance and

safety.

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