

## ***Sportswears with Smart Textiles and Wearable Technologies***

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### ***Abstract***

*The basic materials to construct e-textiles, conductive threads and fabrics have been around for 1000 years. Conductive yarns and fabrics continue to improve and the ranges expand, creating better, more durable and reliable building blocks for new products. Product designers have new options for a complex ecosystem of different material, component and connections to produce better properties including wash ability, stretch ability and new functionalities. The jungle of consumer fitness devices are growing denser day to day. Bio-metric sensors can provide various metrics for athletes to become integral tools moving forward. High-tech textiles in competition sports show prospective research potentials. Smart textiles create textile products that interact by combining smart materials and integrated computing power into textile applications. Wearable technology is become heavily ingrained into professional sports, allowing adverse metrics to be taken into account and utilized within training and allowing for real-time decisions to be taken subsequently.*

***Keywords:*** *Sportswears, e-textiles, Wearable Technologies*

### **I. INTRODUCTION**

New kind of performing textiles especially the electronic ones are now-a-days used in several applications throughout all everyday activities. The textile has become

the supporting platform to integrate the technologies, add more functions to what we wear and exploit high-tech mechanisms. We assist to a shift into textile from a static dimension to a

dynamic that consequently creates new dynamic products [01]. This switch into the textile structure adds functionality but also creates new behavior. An educational activity carried out inside the sportswear Studio Lab of Master Degree in Fashion Studio at School of Design of Politecnico di Milano has been described. The object was to generate a new advanced concept for smart sports application exploiting the potentiality of smart textile and wearable technology.

Challenges using textile integrated wearable devices are stated and addressed in experiments or in explicit recommendations by the works carried out by the authors [02]. Innovative and pervasive monitoring possibilities are given using textile integration of wearable computing components. The 'Fitness Shirts' is one of the examples of a textile integrated wearable computing device. The authors described the technology and algorithms behind the wearable fitness shirt as well as current application areas in sports and medicine. The applicability of the fitness shirt has shown in user studies in sports and medicine.

Success in the international competitive sport is based on equipment besides pivotal factors as training, alienation and psyche. Therefore, a lot of sportsmen and

women look for advantage over their combatant wearing appropriate high-tech textiles. The term 'high-tech-textiles' comprehend compression garment, smart textiles and wearable technologies [03]. Smart textiles are made of materials that can adapt to environmental factors, e.g, phase change materials, which have either a 'cooling' or 'warming' effect depending on environmental temperatures or shear sensitive materials reacting on mechanical changes. Wearable technologies are textiles that have an integral sensor, e.g, shirts for monitoring vital parameters during sports. A lot of research has been done in this field during the last few years and many innovative solutions were brought on the market. Therefore, the aims of the study by the authors were to give an over view on the available products, to find out which products are used by the athletes to figure out the state of current research and to point out further prospective research potential.

Smart clothing fabrics that enable digital components such as battery and light and electronics to be embedded in them. Smart textiles are fabrics that have been developed with new technologies that provide added value to the wearer [04]. Performance enhancing textiles are intended to use in athletics, extreme sports,

and military applications. These include fabrics designed to regulate body temperature, reduce wind resistance and control muscle vibration and all of which may improve athletic performance. Electronic textiles are distinct from wearable computing because emphasis is placed on the seamless integration of textiles with electronic elements like micro controllers, sensors and actuators. The related field of fibertronics explores how electronic and computational functionality can be integrated into textile fibers. A report from Cientifica Research examined the market and identified three distinct generations of textile wearable technologies, namely first generation with a attach sensor to apparel, second generation embedded sensor in the garment and third generation the wearable garment is the sensor.

Health and fitness have been two of the primary market drivers behind a developed country's growth, with activity devices such as the Fitbit or Misfit Shine and Mobile Apps such as My Fitness Pal and Runkeeper reflecting new pattern of consumer behavior driven and enabled by wearable technology. Millions of people are now using these technologies to monitor everything from their eating habits and activity levels to their weight and

sleeping patterns in a bid to better understand and influence their own health and fitness levels. With the introduction of Obamacare, US employees were eager to cut health care costs and had new ways to offer employees' incentives for healthy behavior mean that many were looking to wearable health and fitness monitoring devices to help achieve this. Indeed, the recent moves by some of the key technology players to introduce how important wearable health and fitness monitoring is set to become, as suggested [05].

The technical article by the authors [06], aims to outline perspectives for deployment of smart textiles and wearable technologies in sports clothing and equipment and to indicate areas where integration of smart features may be used to support a brand image. Focus is on wearable technologies and smart textile applications in the broadcast sense, i.e both technologies that can be embedded into clothing and accessories which can be worn on the body. Obmatex works with the following definitions such as smart textiles, wearable technology and interactive textiles.

The basis of the new technology in terms of new functionality is the integration of

textiles and electronics as suggested by ID Tech Ex [07]. From clothing to bandages, bed linen to industrial fabrics integrating e-textiles is being created. The market has been slow to start due to many challenges but with large companies investing heavily and releasing early products, this industry is poised to change very quickly as soon as the right conditions are achieved. With many associated challenges around reliability, performance and comfort, there has been a strong push towards other solutions that can achieve better properties including wash ability, stretch ability and new functionalities. The result is a complex eco-system of different material, component and connection options that are newly available for product designers.

The application of smart textiles finds its exploitations in the development of three research areas: conductive materials, miniaturized electronics and wearable technologies with the use of wireless communication [08]. The research field of wearable and smart textiles encloses different discipline such as biology, physiology, physics, chemistry, microchips, textiles, telecommunication and engineering disciplines along with micro-nano technologies and material sciences [09]. To-day we assist to a self-regulating human-machine system as per

the authors Manfred Clynes and Nathan Kline [10], "The human skin is an artificial boundary: the world wanders into it and the self wanders out of it, traffic is two way and constant".

The skin mentioned above becomes the media, for the interaction and consequently the machine equipped with technology influenced by the technology but without losing its operational essence. It instead reshapes its form in seek of perfection through the homologation. It is because of the technological progress the human body increases its capability to sense as explained [11]. The aims of the work of the authors [01], describes the results of an educational activity carried out inside the sportswear studio lab of Master Degree in Fashion Study at the School of Design of Politecnio di Meliano. In the study students were asked to focus more attention to the achievements of wear ability that concerns the relationship between physical form of the wearable and the human body. This is very important because if well-investigated to get the essence of the paradigm anytime any place by any one by the device as calculated [12-14].

According to the producers of compression garments it is stated that compression

garments achieve positive effects on biomechanical and physiological parameters. The compression garments in the research works of Gill et al [15], served as regeneration tool, where as in other studies the test persons wore the compression garments just during the activity [16, 18]. In some studies the athletes were endowed with compression garments during team sports specific circuit [17, 18], or during endurance training [16]. Purvis et al [19], carried out a study with goal keepers' gloves containing PCM material i.e, phase changing materials. The advantages of smart materials due to biomechanical effects were studied primarily swimming suits. After the work of Toussaint et al [20], on water resistance in swimming the impact of swimming suits design on energy expenditure and swimming kinematics was studied [21]. Dantas et al [22] could show a positive effective concerning water resistance of wet suits. Functional textiles can have a preventive effect either in a physiological way or in a mechanical way. Upton et al [23], could show a positive effect of thermo trainers on persistent knee tendon inflammation. Schmittel et al [24] proved the damping potential of goal keepers' pads. They could show that the padding does not protect the pelvis well enough and propagate to invent

intelligent protectors. There was a moment when Johnson surveyed all the innovations in fitness and health technology being worn by professional athletes and weaned warriors alike the wearable devices, the watches, the apps, the seals, the scanners, the soft ware, the biofeedback machines and serious threats to his fitness business [25]. But rather throw in the towel he realized the world of wearable technology opened a new world of possibilities for him. It could equip him with a vast array of tools to better serve, educate and improve the performance of clients. Technology has become a critical component of the sports industry and in the past year, the two have continued to strengthen their bond [26]. According to Nicola K. Smith [27], analysis of data transmitted to the cloud from increasingly sophisticated sensors is helping teams keep their players at the peak of physical fitness. As per Kieran Loftus [28], wearable technology is become heavily into professional sports, allowing adverse metrics to be taken into account and utilized within training and allowing for real-time decisions to be made subsequently.

**E-TEXTILES:** Electronic textiles are fabrics that enable digital components such as a battery and a light, and electronics to

be embedded in them. Smart textiles or electronic textiles are fabrics that have been developed with new technologies that provide added value to the wearer. Electronic textiles are distinct from wearable computing because emphasis is placed on the seamless integration of textiles with electronic elements like microcontrollers, sensors and actuators. The related field of fibretronics explores how electronic and computational functionality can be integrated into textile fabrics. Performance enhancing smart textiles intended for use in athletic, extreme sports and military applications. These include fabrics designed to regulate body temperature, reduce wind resistance and control muscle vibration, all of which may improve athletic performance. Other fabrics have been developed for protective clothing to guard against extreme environmental hazards, such as radiation and the effects of space travel. The health and beauty industry is also taking advantages of these innovations, which range from drug-releasing medical textile, to fabric with moisturizer, perfume and anti-aging properties. Many smart clothing, wearable technology and wearable computing projects involve the use of e-textiles [04].

The basic materials needed to construct e-textiles such as conductive threads and fabrics have been around for over 1000 years. In particular, artisans have been wrapping fine metal foils, most often gold and silver, around fabric threads for centuries. Many of Queen Elizabeth I's gowns, for example are embroidered with gold-wrapped. At the end of the 19th Century, as people developed and grew accustomed to electric applications, designers and engineers began to combine electricity with clothing and jewelry developing a series of illuminated and inventor necklaces, hats, brooches and costumes. The first ECG bio-physical display jackets employing LED/optic displays were created by Wainwright and David Bychkav. In 1985, inventor Harry Wainwright created the first fully animated sweat shirt [05]. In 1968, the Museum of Contemporary Craft in New York City held a ground-breaking exhibition called Body Covering that focused on the relationship between technology and apparel. The CEO of Exmover at the time in 2005 using GSR sensors in a watch connected via Bluetooth to the embedded machine washable display in a denim jacket and were demonstrated at the Smart Fabrics Conference held in Washington, D.C, may 7th, 2007.

Now we have grown comfortable with carrying technology, and starting to see new benefits in wearing it. So far, health and fitness have been two of the primary market drivers behind this growth with activity/tracking devices such as the Fit Bit or Misfit Shine and mobile apps such as My Fitness Pal and Run Keeper, reflecting new patterns of consumer behavior driven and enabled by wearable technology. Although e-textiles wearable has been around for over a decade, the market has not yet been reached the mass-scale tipping point and remains a long way behind the adoption rates of other wearable. The lack of bulk manufacturing capability and capacity creates one of the biggest barriers to growth [07].

**SMART TEXTILES IN SPORTS:** There was a moment when Johnson surveyed all the innovations in fitness and health technology worn by professional athletes using the wearable devices, the watches, the apps, the scales, the scanners, the software, the bio-feedback machines and saw series of threats to his fitness business. Later he realized that the world of wearable technology opened a new world of possibilities for him. He could equip himself with a vast array of tools to better serve, educate and improve the performance of his clients. Industry

analysts have forecast that a huge number of wearable will be shipped in 2017 compared to the year 2016. Devices that used to be oddly shaped and clunky worn by only competitive athletes, have morphed into stylish everyday pieces worn by casual joggers and stroller pushing parents who just want to track their daily steps and sleep [06].

Adidas introduced the first shoe integrated with technology to measure how a runner was performing back in 1964. Now along with the wrist-worn Fit Bits, Misfits, Whoops, Moovs, Tom Tom and others, there are smart socks, digital shoe insert, smart bras, compression shirts, Tank Tops leggings and shorts featuring bio-metric-tracking sensors. We ‘can think about a bathroom that measures our weight, body composition, BMI index, and even pulse wave velocity. There is a reason that wearable devices have become a favorite gift for employers to give employees. Healthier employees mean lower health care costs. And there are now apps and devices for just about any activity including tennis, golf, skiing, and swimming. But even as the industry grows, there is debate of how useful or well-used the equipment really is. Many if not most, simply record one’s steps, heart rate, and may be blood/oxygen levels. At

the Consumer Technology Associations CES 2017 Conference, Sports Techie counted 14 major sports technology announcements. Notable product launches included STRIVR, a platform for VR Training that utilizes 3D football footage, and Under Armors Athletes Recovery to produce healing far infrared energy. Epidermal electronics are poised to make a huge impact in his space. Objective data capture of fatigue levels, asymmetry on the body recovery and hydration has huge potential for injury prevention optimization. Biometric sensors that can provide these metrics for athletes will become integral tools moving forwards [25].

Innovative and pervasive monitoring possibilities are given using textile integration of wearable computing components. Fitness SHIRT as one example of a textile integrated wearable computing device. Using the Fitness Shirt, the electric activity of human heart and breathing characteristics can be determined. In the Spring Link [02], an overview of the market situation, current application scenarios and related work has been given. The technology and algorithms behind the wearable Fitness Shirt as well as current application areas in sports and medicine has been described.

The applicability of the Fitness Shirt has been shown in the user studies in sports and medicine. The discrepancy of performance among competitive athletes is getting smaller and smaller. Therefore, wearing high tech textiles could help to get advantages over competitors. For this reason, a lot of investigation has been done on developing high tech textiles that support the athletes to better performance [26].

Several studies have been done to prove the effectiveness of compression garments, in particular the improvement in performance during training and regeneration. To evaluate the effect the following parameters were analyzed: physiological parameters as heart rate, VO2 max, blood lactate concentration, and bio-mechanical value like muscle vibration and performance. These textiles work according to the physical law of diffusion and impulse. The effectiveness of the material itself up to now mainly proved in the laboratory tests. Only a few manufacturers test the whole product on test persons. But according to the interview partners the cut of the clothes plays an important role for the performance. The physiological effect of functional textiles is to support the athletes

in their regulations and protect them against cold and wind [02].

Often applied in sports textiles are phase changing materials (PCM), which can change their state of aggregation depending on environmental temperature from solid to liquid or solid to gases. Thereby the textiles save warmth energy from the warmer body and give it back if required. The advantages of smart textiles/materials due to bio-mechanical effects were studied primarily in swimming suits. The impact of swimming suits design on energy expenditure and swimming kinematics was studied. One of the wet suits had a mechanochemical coating. This coating was advantageous in respect of the water resistance effect and the measured linear velocity of the pelvis. Functional textiles can have a preventive effect either in a physiological way or in a mechanical one [03]. The compression technology has been applied for medical purpose long time ago. Therefore the grade of innovation is low. In most of the studies the amount of test persons is too low to get statistical significance. The different attitude towards compression garments of the athletes might be due to the lack of experience. According to the experts, the grade of innovation of smart textiles is very high. The performance enhancing

effect of these clothes is argumentative. This could be due to the facts that most of the studies were done in the eighties but in the mean time a lot of new products have come up.

**WEARABLE TECHNOLOGIES IN SPORTS:** Currently there is a great inclination to modify sports and well being concept changing the technology in wearable especially thanks to the huge developments of technologies in the field of smart textiles. Textiles today are materials with applications in almost all our activities. Fibers, yarns, fabrics and other structures with added value technology having functionality developed for a range of applications and the textiles have become an important platform for high-tech innovations. Smart textiles create textile products that interact by combining smart materials and integrated computing power into textile applications. The introduction of smart materials and technology in textile structures offers an opportunity to develop textiles with a new type of behavior and functionality. Smart textiles and computing technology are introducing a shift in textile from a passive to a dynamic behavior from textiles with static functionalities to products that exhibit dynamic functionalities.

The term Wearable technology, fashionable Electronics or Smart Garments is associated to those clothing and soft or hard accessories which integrate electronic components or which are made of smart textiles. Smart textiles are the results of a disciplinary approach that creates an interaction and overlapping of researchers in different fields such as textile, design and technology, chemistry, physics, material science and computer science and technology. A smart wearable textile system is a simple platform able to sense both human body and environment in presence of different kinds of sensors. A wearable is a device worn on the body that incorporates the intelligence into the clothes. This typology of device is able to sense, communicate, navigate but also actuate other devices. The research field of wearable and smart textiles encloses different disciplines such as biology, physiology, physics, chemistry, micro technology and material science, industrial sectors like medical devices, electronics, microchips, textiles, telecommunications and engineering disciplines. Wearable technologies and smart textiles cover a very wide field of applications: (a) monitoring body vitals for health (b) sports purpose (c) source of light and (d) augmented reality. Today we assist to a self-regulating human-machine system in

which the human skin is an artificial boundary, the word wanders into it and the self wanders out of traffic is two way and constant. The skin is the technology itself and is our intelligent covers, the platform that connect us with the surrender. In this way the human body becomes the media for the interaction and consequently the machine equipped with technology influenced by the technology but without losing its essence. It instead, reshapes its form in seek of perfection through the homologation. It is for the technological progress the human body increases its capability to sense [01].

Technology has fundamentally changed sport, adapting the sports we spend hours watching. Through technology we are now able to make calculated decisions on our favorite players with stats being relayed to us throughout broadcasting. Wearable technology is become heavily ingrained into professional sports allowing adverse metrics to be taken into account and utilized within training and allowing for real-time decisions to be taken subsequently. Football has seen a vast change since the beginning, with so much technology being used to enhance the game not only for players but for spectators too. Tech Company Stat Sports created the Viper Pod, a device widely

used through the world with football teams as well as rugby teams. Weighing less than 50g the device is mounted onto a vest and contains GPS module, accelerometer, gyroscope, digital compass and heart rate monitor [28]. These metrics are then transferred to other devices which enable coaches to make real-time decisions dependent on the player's real-time performance.

Wearable technology has also been created for goal keepers that helps monitor and optimize their performance. The Catapult Optim Eye G5 enables users to track goalkeepers' movement as well as movement speed and a host of other stats. The device can also track acceleration, direction and position and probably the most crucial is the impact of collisions, all at a rate of 800-900 data/second, helping to mitigate the circumstances that can conclude in injury.

With the increased emphasis of sponsors producing content to enhance fan engagement, and Catapult Sports and Stat Sports holding the insights into intricate players' performance data, the opportunity for unique, engaging and creative content permits itself to potential investors. The impact of technology has had with wearable and performance analysis

presents opportunity for investment and sponsorship deals. Sports underlying influence throughout society presents direct opportunity to engagement with fans and spectators that will no doubt become a tangible and lucrative position. An increased amount of emphasis has been placed upon players' safety within American Football, with increased technology enabling more detailed reports on players' health, and more technology is being created to ensure players safety through the season.

One of the latest consumer wearable devices available is the Tom Tom Touch Tracker, which has the ability to read the person's body composition. Using some of the latest technology, the device sends electrical impulses through the user's body that measures the amount of muscle and fat in the body. As wearable technology still remains a relatively new feature in sports and an enlisted feature in many sports, the use of sponsorship could trigger an enlarged aspect of fan engagement. Wearable technology in sports has become common place with teams across multiple sports looking to gain advantages and improve performance and mitigating risks of injury. Across all levels of sports, wearable technology is becoming a prominent feature throughout.

Analysis of data transmitted to the cloud from increasingly sophisticated sensors is helping teams keep their players at the peak of physical fitness [27]. Leicester City Football Club, currently clinging to the English Premier League's top slot against all odds has also had the fewest injured players over the season, a fact that may have a lot to do with the club's clever use of the technology. Southampton FC Scott makes its players wear GPS units during training and Alek Gross, the Club's head of sports science, said that players have experienced fewer soft tissue and overuse injuries since introducing the technology.

Another tracking device manufacturer said that their biggest European Clients reported having only 20 muscular injuries last season once they started using technology compared to 44 the previous season. Wearable technology is able to monitor that load on a day-by-day basis to ensure those players are not just injury-free but in peak condition for competition as reported by Corin Palmer.

## CONCLUSION

Many smart clothing, wearable technology and wearable computing projects involve the use of e-textiles. Millions of people are now using these technologies to monitor

everything from their eating habits and activity levels to their weight and sleeping patterns, in a bid to better understand and influence their own health and fitness levels. Many developments require considerable work to reach a majority which can ensure a robust product that is both as functionally reliable and washable, etc, as consumers expect. Technology gets in the way if we think technology is perfect and it has become a critical component of the sports industry. The term high-tech-textiles comprehend compression garment, smart textiles and wearable technology.

The introduction of smart materials and computing technology in textile structures offer materials and computing technology in textile structures offer an opportunity to develop textiles with a new type of behavior and functionality. Across all levels of sports, wearable technology is becoming a prominent feature throughout. Wearable technology still remains a relatively new feature in sports and an elitist feature in many sports.

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