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Original Article

24 hours monitoring the trend of some physical parameters in children during sport, school, and leisure activities through the latest wearable technology system generation. An exploratory approach.

IZZO R.[1], LUZI A.[2], HOSSEINI VARDE'I C.[3], CEJUDO A.[4], CRUCIANI A.[5], GIOVANNELLI M.[6].
[1,2,3,6] Department of Biomolecular Sciences, School of Sport and Health Sciences, University of Urbino Carlo Bo, Urbino, PU, ITALY.
[1,4,] Grupo de Investigación Aparato Locomotor y Deporte. Departamento de Actividad Física y Deporte. Facultad de Ciencias del Deporte, Campus de Excelencia Mare Nostrum. Universidad de Murcia, San Javier, ESPAÑA.
[5] Research and Development Department, K-Sport Universal, ITALY.
Performed by **ARGS**, Advanced Research Group in Sport, School of Health and Sport Science, DISB, Urbino University Carlo Bo (IT) with K-Sport Universal, ITALY.

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Abstract
This research aimed to monitor the trend of electrocardiographic activity and establish the quality and quantity of the physical activity performed for an entire day (24 hours) during a week by a group of children using, an innovative, wearable, and comfortable device the K-Sport-Shirt (Patented by K-Sport Universal, Montelabbate, PU, Italy); it's one of the first approaches all over the world with textile sensors to have obtained CEMED certification; an informatize shirt equipped with a positioning system, receiving and sending data from/to four satellites systems, normally is only the GPS, plus three triaxial inertial sensors both interconnected by a sensor fusion firmware. The positioning device is called K-AI the shirt contains some electrocardiographic sensors with medical official validation too. Twelve children between the ages of 6 and 13 belongings to two sub-elite football sport clubs Fossombrone Academy, and Montecchio Academy, from Italy, participated in the study. The main purpose was to monitor, heart rate responses to establish internal load values in different situations on the whole day such as school, sports, and leisure time activities (using electronics devices too), as well as during sleep, which in any case will be developed and deepened in a second-time investigation to evaluate pre-sleep activities and their influence on the sleep itself. In addition, during the sporting activity, in this case, football, the commitment due to the training work proposed for the measurement of the external load was detected using the parameters of the distance traveled, travel speed, and others considered qualifying for the surveys carried out, thanks to the cited K-AI device.
Keywords: Children environment, Correct workload, Wearable device, Ecg h24X7, K-AI, Sport, School, Leasure time, Electronic games, Sleep.

Introduction

The anatomy of children or young adolescents is different from adults, they have smaller internal organs. The heart also is smaller, and the systolic output, expelled with a single beat, is therefore also decreased (about 70 ml for the adult). To compensate for the lower systolic stroke, the heart maintains a faster beat and a higher maximum heart rate (HR). In fact, unlike the 195-200 btm of a 20-year-old, a child can even reach 215-220 btm. (Pirani, 2018). The HR, at rest, is approximately between 60 and 80 btm. During exercise, the increase in HR is directly proportional to the increase in exercise intensity. This is until the subject is close to "exhaustion", the moment in which the HR stabilizes reaching the maximum individual frequency, which is the highest value that can be reached and which obviously cannot be maintained for too long, during a commitment that leads to exhaustion (Jack H. Wilmore et.al, 2005). Many children are adversely affected by biological and psychological stressors.

The impact of stress can be observed in the symptoms of somatic disorders, poor emotional regulation, anxiety, depression, and health problems. Additional stressors that children encounter can also result from family separations, family movements, violence, experienced or observed, directly or in other ways, school changes, school pressures, competition, and peer pressure. School pressures (for example, proficiency tests, nowadays required to a sometimes excessive extent) have increased, albeit probably easier than in the past, while school activities that can be relaxing (for example, recreation, physical education, art, and music) decreased in many schools in favor of a density of "(per-) formative" commitments linked to various study activities. Children's fears and stress reactions can manifest themselves in many different ways, such as behavior changes, anxiety, depression, psychosomatic disorders, sleep problems, and illness. A brief daily stress management intervention together with a correct dilution or proposition of training commitments together with correct psychological

Corresponding Author: . RICCARDO IZZO, E-mail: riccardo.izzo@uniurb.it

requests, in our opinion, could significantly reduce the symptoms of anxiety and improve HRV (Bothe et.al, 2014, mod. Izzo R., 2022). The purpose of this study, in essence, is aimed at specifically monitoring the children belonging to two football Clubs (A.S.D. Montecchio, from now Club 1, and F.C. Forsempronese, from now Club 2, Marche, Italy) during various activities they practice during a whole day, in particular by monitoring the HR (internal load) during school, sports and leisure activities, as well as during sleep. It was very interesting to evaluate the results obtained which sometimes have given figures that were not entirely predictable, as we will see in detail in the tables shown below, and which certainly can help to measure more carefully all the commitments that are normally administered to children today, not always correctly and adequately for different individuals and objectives, sometimes coming to consider them unethically only as "performance machines", in a broad sense of meaning and not only on sport results. These results can therefore be of considerable help for kids management by parents in the first place, relatives and teachers in general as well as for sports instructors who are often those who find themselves requiring a significant commitment, sometimes perhaps even at the limits of possibilities for individuals in different ages and the results will show significantly unexpected elements of cardiac commitment in certain research activities.

We also believe that in the specifics of the sport activity investigated, in this case in soccer, the specific commitment due to the proposed training work was detected, analyzing various parameters useful for modulating the most suitable and weighted educational proposals for individuals of different ages in training (specific qualification of the proposed work-out), drawing useful information from elements such as distance traveled (volume), travel speed, acceleration, deceleration (intensity), frequency of didactic proposals, recovery periods/work pause (density), etc. detected with the use of K-AI. Furthermore, in a future study, we intend to evaluate the influence of pre-sleep activities on the HRV and electrocardiographic trends during it. We are convinced, as some specific literature argues too, that the very engaging activities practiced before going to sleep, even more so at a young age, can severely affect the normal course of sleep itself, and also being able to create problems as well as the variability of the cardiac rhythm and lead to other organic dysfunctions. This study obtained informed consent from the families of the participants who signed a release. As mentioned above and in more detail, the data relating to daily life activities such as school activity, and sports activity were examined, measuring the impact of the load during them the physiological impact produced, in leisure time, including the various typical activities of the same, such as electronic games, hours of rest and sleep, the latter monitored, by the parents of the participating children. This is to obtain a wider vision of the management of the typical day of the individual under examination to study the parameters of the research over 24 hours for seven days. Sleep has been detected in an exploratory and quantitative way, as mentioned above, but it certainly deserves more in-depth attention and will be the primary focus in a further step of our research, given its complexity and is a phenomenon that is anything but passive, homogeneous, and static. Three of the children were unable to wear the device, which despite its very small size was annoying to them in the supine position when taking sleep due to the interscapular positioning of the K-AI (an extra device inserted in a shirt special pocket). It's well known that the electrocardiogram is an indispensable diagnostic tool for detecting abnormalities of heart function, in particular those relating to heart rhythm, conduction abnormalities, myocardial oxygenation, and tissue damage (W.D. McArdle et.al, 2009).

The basic principles for interpreting the ECG in children are almost identical to those used in adults. Between birth and adolescence, there are gradual anatomical and hemodynamic changes. These changes cause substantial differences in heart rate, morphology, voltage, and duration of the waves, in the P-R and QT intervals, based on the age of the child. In addition, there are some features regarding the pediatric ECG that are considered physiological: marked respiratory arrhythmia (increase in heart rate on inhalation and decrease in exhalation), physiological low atrial rhythm, short P-R (in case of ventricular pre-excitation with clear presence of the delta wave), narrow ventricular complexes (in the pediatric age the finding of delayed right bundle branch conduction is frequent), first and second-degree atrial ventricular blocks of the Wenckebach type, especially nocturnal and in trained subjects, sporadic atrial and ventricular extrasystoles, right axial deviation, prominent Q waves in the lower and lateral leads, early repolarization (slight over leveling of the ST segment with early T wave appearance), negative T waves V1 to V4 (up to 12 years), prominent U wave (Agnetti et.al, 2016). As for differences between genders, although in the present study there is only one female subject, experimentally, N. Armstrong et. al (1991) and W.D. Mc Ardle et. al (2009), by analyzing the relative "physical activity patterns defined by continuous heart rate monitoring" of elementary school children, was anyway able to note that there are no large differences in HR between males and females during the various activities analyzed. As far as video games are concerned, there have been several studies that have dealt with the health risks deriving from video games, which we have taken into consideration, which have caused convulsions, psychological disorders, and other health problems (Gwinup et.al, 1983), among the most notable, one is a significant increase in heart rate, as evidenced in some cases in our study with peaks at the limit of danger.

Means and methods

In this study, with a little investigation in literature, the sample was chosen from among some children belonging to two amateur football clubs (subelitè) in the province of PU, Marche, Italy. The work aimed to monitor the participants during multiple activities, in addition to football, throughout the day (24 hours a day).

The data relating to daily life activities such as school activities, and free time were examined, thus including sports, electronic games, and sleep. The goal was to obtain, at least initially, detailed information on the daily trend of the individuals examined regarding the physiological deviations from the condition of individual normality through continuous electrocardiographic results of the activities described above. The research wants to be a representation, through a sharp analysis of data, of the activity and also of the emotional involvement, in our case through the BPM and the ECG, which produce the activities carried out daily by the participants to establish whether these moments are, even at the physiological-cardiac level, adequate or not and bearers of plausible loads that could normally be expected, as well as useful for alerting (the software can do it automatically) on any problems in progress.

All in a simple, economic and direct way. In truth we found ourselves in front of some interesting and partly unexpected results, which allowed us to better photograph the real load borne by individuals of those ages, the real individual involvement linked not only to the different activities undertaken but also to the emotional aspect that we believe that it is directly connected with the physiological one and that precisely the data collection presented elements of considerable interest because they were substantial, as told above, rather unexpected in some cases. This study, given the extreme simplicity and cost-effectiveness of the wearable systems used, in the next steps will also be applied to different types of individuals who, it seems to us, are well suited to the focus of the research, such as people with disabilities, adults and elderly people with particular problems, cardiological, accidents, and more, from which it will be possible to draw elements of attention, particularly in the dosage of the activity to be proposed, both of normal life management and motor and/or technical proposals thanks to simple periodic monitoring and effective for a work-out functionality, as well as from a medical-health point of view sometimes also life-saving elements, being able to interact with the subjects in "Live" (already available), and therefore with real-time monitoring and no longer in post-production, as in the present case proposed here.

This would also be useful in raising the awareness of educators, parents, and employees in the management of groups of individuals of various kinds and activities that with the use of simple yet highly advanced wearable tools with a very sustainable impact on various aspects such as economic, ergonomic, of reliability, it is possible to obtain truthful information on the real "live or post" response of individuals concerning the activities undertaken by them with any physiological sound and visual alerts. The continuous monitoring in moments that will be determined and detected will be useful we believe in accompanying the life of the young subjects by suggesting and proposing to them, where possibly useful and/or necessary, methods of approach for the crucial phases of their individual psycho-physical needs to which they are subjected, to facilitate the most correct approach to such moments which, although seeming without physiological relevance to the effects, as shown by the data of the presented research, and that we feel can strongly influence the future psycho-physical growth of boys in a significant way. The analysis protocol for children was proposed to the members of the following football categories (in an age range from 6 to 13 years): Piccoli amici category: year of birth 2014-2015, Pulcini Category: year of birth 2010-2011, and Esordienti category: year of birth 2008-2009. In the sample examined by the following study, there is a prevalence of males over females. The group was made up of eleven males and one female aged 7. We considered the variegation of the individuals used to be a guiding and indicative element for the next steps of the study and therefore it should be taken as such even though we are aware of the unreliable statistical validity on which we will work as mentioned below. Therefore, also that of gender will be an element that in the next research steps will assume equal numerical values, certain that this difference will pose interesting questions to researchers. The subjects examined were previously made aware, with ad hoc explanations, of the activities to be carried out. Furthermore, all subjects were informed of the benefits and risks of the investigation before signing an institutionally approved informed consent document to participate in the study. The data collection followed the principles outlined in the Declaration of Helsinki. In detail, the following activities were identified:

- **Sports activity:** the children had two to three training sessions per week, as per the protocol of the club they belong to, with a duration of 2 hours (pulcini and esordienti) or an hour and a half (piccolo amici).

During these sessions, they performed technical, coordinative, and situational exercises and matches. One of the children analyzed (born in 2010) carried out two weekly training sessions with the goalkeeper coach for one hour because he was already initiated by the staff in this role. Furthermore, some of the subjects analyzed participated in the match held over the weekend; another element that will be addressed shortly and will also be linked to the impact of the roles played by individuals on the pitch in those situations, although a clear division into roles in these ages is not yet desirable (Izzo R., 1982).

- **School activity:** in this phase the parameters related to the activities carried out during school hours were analyzed (lessons, questions, and school tests);

- **Rest activities:** finally, in this last phase leisure/rest-activity (Leisure-time) was considered.

In particular, this activity took into consideration the parameters of children during the time spent at home, in carrying out schoolwork, in moments of leisure (such as games with electronic devices and television viewing), and during the sleep phase.

Procedures

The following tools were used to analyze the activities of the children who participated in this study:

- A Dell computer with Intel Core i5, 500 G SSD capacity, 512 GB RAM installed: 8 GB dedicated graphics card, Windows 10 Pro,
- K-Fitness software, K-Sport Universal, Montecchio, Italy, GPS Worker;
- Comparative database: www.k-sportonline.com
- An electronic device (K-AI Wearable Tech) with a detection frequency of 50 Hz for GNSS satellite tracking (which uses four different satellite systems, not just GPS) and with Sensor Fusion (SF) technology that integrates the system's satellites detected at 50 Hz with some 3D inertial sensors with a detection frequency used, to facilitate synchronization with other devices, of 100 Hz effective even with ceilings of approximately 4700 Hz resident (Fig. 1).
- A sensorized T-shirt equipped with certified textile sensors in the medical field to detect electrocardiogram and ventilation in a non-invasive way and in real-time (under experimentation) (Fig. 2).

Figure 1: K-AI Wearable Tech

Figure 2: Sensorized T-shirt

The participating children wore the tools indicated above to monitor the electrocardiographic evidence (assessed by a cardiologist) on kinematic parameters (eg speed) during the various activities of the day previously specified. The intervention and collaboration of the family were decisive as they transferred the data at the end of each day of detection present in the memory of the K-AI Wearable using the GPS Worker software, during the entire study week and noted all the activities carried out by the children in a "diary", to be able to synchronize the electrocardiographic data with the activities carried out at different times of the day. Subsequently, through the K-Fitness program, the files received, from all the surveys, were analyzed and divided according to the tasks performed. Finally, the data were extrapolated from the comparative database k-sportonline.org to be able to carry out the mathematical analyzes we have considered a priority for this phase of the study. The parameters taken into consideration are the following:

- MAXIMUM HEART RATE (HR max) analyzed thanks to the involvement of a cardiologist: it is the highest number of heart beats per minute (bpm) during the various activities;
- HEART RATE AVERAGE (HR) analyzed thanks to the involvement of a cardiologist: it is the result taken from the average between the maximum heart rate (Hr max) and the minimum heart rate (HR min);
- DISTANCE COVERED (D): is the space traveled by a subject during its movement;
- DISTANCE COVERED AT DIFFERENT SPEEDS:

a) D> 16 Km / h: is the space traveled by a subject at a speed exceeding 16 km / h;
b) D 9-12 Km / h: is the space traveled by a subject at a speed between 9 and 12 km / h;
c) D 12-15 Km / h: is the space traveled by a subject at a speed between 12 and 15 km / h.

- DISTANCE COVERED ABOUT ACCELERATION AND DECELERATION:

a) D Acc> 3 m / s2: is the space traveled by a subject at an acceleration greater than 3 m / s2;
b) D Dec <-3 m / s2: is the space traveled by a subject at a deceleration of less than 3 m / s2.

At a statistical level, the only element that was considered useful in this exploratory study was the mathematical average

Discussion

In presenting the results of the variables selected for this study, the following criterion was followed:

- Analysis of the age, average age, and gender prevalence of the children examined;
- Analysis of the parameters HR max, average HR in school, and free-time activities;
- Analysis of parameters HR max, average HR, D, D> 16 Km / h, D 9-12 Km / h, D 12-15 Km / h, D Acc> 3 m / s2, D Dec <-3 m / s2 during the following activities: training and match.

The average age of the children who joined the project was 10.3.

Analysis of HR max (peak) and average HR parameters in school and sedentary activities

The first analysis proposed concerns to school and free-time activities. In detail, during the first activity, the values relating to the entire school day were examined with particular subsequent attention to the conduct of school checks and interrogations where children were subjected to a greater level of attention.

Table 1: Average and maximum (peak) HR at school

Avg HR and maximal (peak) at school		
SUBJECTS	**Avg HR**	**HR max**
1	90	**174**
2	106	**222**
3	91	**184**
4	116	**226**
5	115	**211**
9	109	**217**
10	**125**	**234**
12	113	**201**
AVERAGE	**108**	**209**

By analyzing the HR values in table 1, it can be seen that children are subjected to constant attention and consequent emotional state throughout the school day. Considering that the optimal value of the mean HR in children aged 6-13 years oscillates in a range of about 80-120 bpm, it can be deduced that the subjects examined show both average and maximum HR values higher than the values of reference. To assess in detail the cardiac behavior of children, in a state of maximum emotionality and school concentration, the same parameters listed above were evaluated regarding the progress of school checks and interrogations (both at a general level and specifically for every single individual).

Table 2: Average HR during interrogations and school tests

HR AVERAGE DURING SCHOOL INTERROGATIONS AND CHECKS							AVG
SUBJECT 1	Avg HR	89	97	85	136		**102**
	HR max	158	133	112	**250**		**163**
SUBJECT 5	Avg HR	110	115	119			**115**
	HR max	211	186	**212**			**203**
SUBJECT 9	Avg HR	125	101	105			**110**
	HR max	**202**	181	170			**184**
SUBJECT 10	Avg HR	119					**119**
	HR max	**220**					**220**

From the data collected, different in several surveys, as shown in table 2, an increase, albeit not significantly, in the average HR compared between the interrogation and the checks and the overall school day is shown. Going into the details of the individuals, as regards the interrogations and school checks, the trend of the average HR and HR max compared between the various days appears to be the following. By visualizing Table 3, it can be observed that during the school checks and interrogations, the HR reached high peaks, probably due to worry and tension. In conclusion, each child, reached a bpm level above the average as can also be seen from the ECGs Fig. 3.

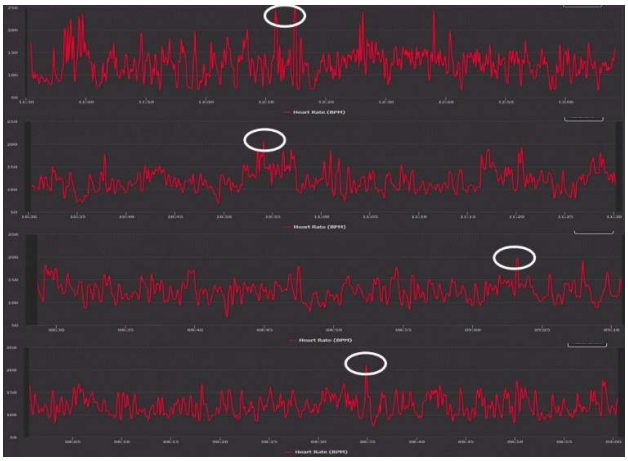

Figure 3: ECG of the most significant individuals during school tests and interrogations.

During the second analysis, namely that concerning the "sedentary" leisure-time activity, the values relating to both moments of leisure such as watching television, the use of computers, and other electronic devices were examined. Greater attention will be paid to the analysis regarding the use of different electronic

devices, where children have been subjected to different emotional states and consequently to variations in rhythm and heart peaks (Table 3).

Table 3: Average HR of children when using electronic devices and watching TV

AVERAGE OF CHILDREN'S HR DURING THE USE OF ELECTRONIC DEVICES AND TV WATCHING		
SUBJECTS	**AVG HR**	**HR max**
1	77	131
2	102	192
3	117	182
4	112	153
6	90	168
7	94	201
8	126	219
11	139	218
AVG	**107**	**183**

From this first generic analysis, it can be seen that the average HR max of children during the use of electronic devices and watching TV is high compared to the average reference value (120 bpm). However, the use of mobile phones, computers, and video games rather than simply watching television can cause different reactions, stimuli, and emotions in children and consequently different heart rate peaks.

Table 4: HR when using electronic games and watching TV

HR WHEN USING ELECTRONIC GAMES AND WATCHING TV											
SUBJECT 1	AVG HR	74		76							
	HR max	144	110	140							
SUBJECT 2	AVG HR	97	129	93	93	98					
	HR max	174	235	231	156	164					
SUBJECT 3	AVG HR	117									
	HR max	182									
SUBJECT 4	AVG HR	127	96	119	115	94	121				
	HR max	185	124	156	175	114	164				
SUBJECT 6	AVG HR	84	101	128	109	90	42	100	87	82	78
	HR max	128	231	162	231	174	122	185	171	154	125
SUBJECT 7	AVG HR	98	90	95							
	HR max	188	164	250							
SUBJECT 8	AVG HR	136	124	128	112	129					
	HR max	224	222	222	214	214					
SUBJECT 11	AVG HR	133	139	144							
	HR max	214	215	224							

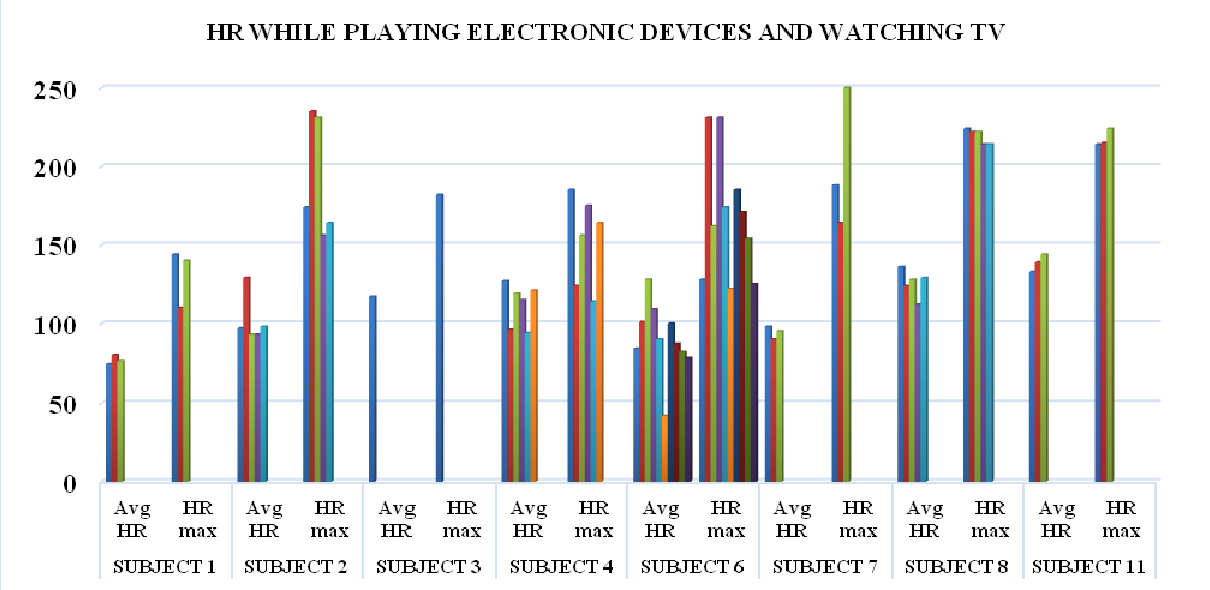

Figure 4: HR when using electronic games and watching TV

Excessive exposure to technology (cell phones, video games, tablets, TV) by children can lead to attention deficit, (Gwinup G.et al.) Increased impulsivity and decreased ability to self-regulate, can result in the child to excess levels of tension and consequent increase in heart rate and therefore probably additional negative stress. Furthermore, the use of technology limits movement certainly this, as also reported in the literature, can affect the motor development of children. Observing table 4 and the relative figures 3 and 5 it can be seen how these technologies have led to peaks in HR during their use. Overall, electronic games caused higher cardiac acceleration than simple television viewing. However, there have been episodes (such as watching the Italy match during the 2020 European football championship) that have generated very high peaks. In detail, subject 2 detected the highest HR max value during the use of electronic games (235 bpm peak) while during television viewing it was subject 7 (250 bpm peak during the game !!). The figure below, it's shown the trends and relative cardiac peaks of the subjects indicated above through the ECG.

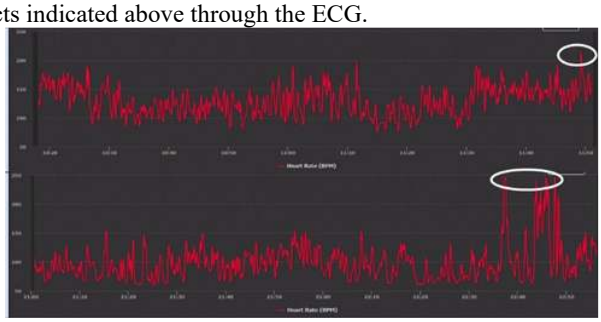

Figure 6: ECG of children 2 and 7 while using electronic games and watching TV

After examining the children's moments of leisure, the data relating to sleep were observed. The children who recorded their heart rate during sleep were the following:

Table 5: HR during sleep

HR During Sleep			
SUBJECT 1	Avg HR	62	
	HR max	101	
SUBJECT 4	Avg HR	106	
	HR max	**130**	
SUBJECT 8	Avg HR	69	79
	HR max	117	100

As shown in Table 5, the children recorded peaks in HR even during sleep and this may also derive from the activities carried out during the day, as well as from personal states that are difficult to identify. Concerning the latter issue, we can observe how most children suffer from the use of technology, games, and devices. It is now known that nowadays the use of these tools is also the prerogative of children under the age of those subjected to research, and from our surveys, albeit initial, exploratory, and based on heart rate and related ECG, we can certainly hypothesize that these Practices, if not planned, can negatively affect the state of physical and mental well-being with the onset of at least an increase in anxiety, attention disorders, and consequent academic performance and most likely on the quality of sleep.

During the third analysis concerning sports activities, values such as HR and external load were examined: HR max, HR average, D, D> 16 Km / h, D 9-12 Km / h, D 12-15 Km / h, D Acc> 3 m / s2, D Dec <-3 m / s2 during the following activities: training and match. As regards the HR max we can see, through the table below, that there was no substantial difference between training and the game, finding very similar average values, which from the point of view of sports performance and certainly a very positive finding because it means that the normal emotionality that increases during the practice of championship matches, with a relative decrease in efficiency, has not occurred.

Table 6: Average HR max during training and matches

AVERAGE OF HR MAX DURING TRAINING AND MATCHES	HR max
AVERAGE TRAINING	210
AVERAGE MATCHES	207

Analyzing in detail the training sessions of the children, we can see, as shown in table 7, that the HR max given the motor activity and the consequent physical effort carried out, tends to increase reaching quite evident peaks as, for example, in the case of the subject 12.

Table 7: Average HR during training

AVG HR DURING TRAINING		
SUBJECTS	AVG HR	HR max
1	145	209
2	133	208
3	136	195
4	134	193
5	125	204
6	128	221
8	129	202
9	124	209
10	129	213
11	133	211
12	141	249

In addition, considering these data, we can see that the HR max of child 12 reached high peaks (249 bpm). This could be due to the constant emotions that the subject under examination had to manage during the phases of sudden increase e of the FC, such as a goal scored, a goal immediately and the eventual defeat of his team during the match played in training. In the figure below we can see the ECG of child 12 with the relative peaks mentioned above.

Figure 9: ECG of individual 12 during training

As regards the **external load**, the distances traveled by children during training sessions and matches were analyzed. Taking into consideration the values, the total average of the activities carried out in the sports field was carried out as can be deduced from Table 8 below.

Table 8: Total average of distances covered by children during training and matches

TOTAL AVERAGE DISTANCES COVERED BY CHILDREN DURING TRAINING AND MATCHES		
TRAINING	D (m)	4662
	Dist > 16 Km/h (m)	80
	Dist 9-12 km/h (m)	552
	Dist 12-15 km/h (m)	263
	Dist Acc > 3m/s2 (m)	50
	Dist Dec < -3m/s2 (m)	48
MATCHES	D (m)	4810
	Dist > 16 Km/h (m)	206
	Dist 9-12 km/h (m)	877
	Dist 12-15 km/h (m)	500
	Dist Acc > 3m/s2 (m)	48
	Dist Dec < -3m/s2 (m)	58

Analyzing the data in table 8, it was possible to note a difference between the training sessions and the match as regards the values of the distance traveled in correlation with the respective speeds (> 16 km / h, 9-12, 12-15). In matches, the subjects examined traveled greater distances at a speed> 16 km / h, between 9-12 km / h, and between 12-15 km / h compared to the training sessions. This could derive from the fact that during training, children carry out activities in small spaces, something as small-sided games, and perform various exercises covering short if not very short distances such as technical and motor coordination exercises, which normally have a shorter duration. Unlike this, during the game, the playing fields are much larger and the children reach higher speeds, having the possibility of covering greater distances by performing multiple stretches during the race. This suggests that in games children are subjected to efforts for which they have not been well prepared during training. A monitored work, in our case with data such as heart rate and workload, will certainly give objective feedback on the weights of the preparation work compared to those of the race, which will allow for a more adequate and specific training construction.

Conclusions

With the following study, we wanted to test the effectiveness and establish the importance that innovative technological tools such as Wearable Technologies and in this case the sensorized T-shirt, in the detection of parameters relating to the internal load such as heart rate and external load concerning the distances traveled at different speeds. In particular, the objective of this study was to analyze the parameters listed above during the various activities (school, sports, and sedentary) by the sample of children being examined. Thanks to the values detected by the device it was possible to follow the detailed cardiac trend throughout the day and for several days for monitoring both the relationship with the activities carried out by the child and also the physiological trend of the same in each of the events. investigated. Having to summarize, the observations addressed to each of these we can deduce that:

- During school activity, the subjects noted an increase in heart rate mainly, in moments of greatest tension such as checks and interrogations. This demonstrates how the mental load (making complex decisions, public spending asking tasks) decreases HRV and consequently increases HR.

Referring to the data extrapolated for the following study, the greatest peaks identified by children during the pressure due to school checks and interrogations are placed between 220 and the risky 250 bpm;

- During the sedentary activity, however, the children performed multiple types of actions such as schoolwork, electronic games, and TV viewing.

Analyzing each of the following aspects, it emerged that greater involvement and consequently increased heart rate occurred during the use of electronic devices and television viewing. Furthermore, some phenomena can cause greater involvement and a high rate of emotion (such as, for example, watching a movie or a football match). Precisely about this last aspect, a fairly evident HR peak of 250 bpm was detected due to watching the Italy match during the 2020 European Championship. During the phase of maximum rest or sleep, not all children (3) have carried out the detection of the heartbeat using the device, as this is an annoying tool to wear at night, especially in certain positions. However, carrying out measurements during the night could be useful and at the same time important in detecting any cardiac problems (for example a possible cardiac arrhythmia in childhood and adolescence). Finally, the last activity considered was sports. Thanks to this analysis, it was possible to observe how the HR during training and subsequent match does not differ significantly. This is because both cases involve the performance of the motor activity by the subjects under examination, an activity that causes a normal increase in bpm and that can detect peaks or actions that can bring your team into a situation. of relative advantage or disadvantage.

Concerning the external load, it has been possible to ascertain that child predominantly have traveled greater distances with multiple speeds, differently from training. This is due, in our opinion, that during the match phases, the subjects have the opportunity to play on wider pitches and consequently travel more meters at a faster speed, unlike the training. The fact of almost similar physical performance between training and match can be considered positive from a purely methodical aspect, optimal as it would mean that the training is in tune with the demands of the race, but on the other hand, it could also be considered that the age of the participants leads them not to make many much strategic calculations in the management of personal possibilities, but always try to have fun by giving everything that is in their ability, a lack of maturity in managing one's stats and abilities.

The wearable system used has also generated very interesting data, in a couple of cases highlighting alerts that suggested a more careful medical specialistic analysis, as well as very useful elements such as feedback on the proposed work and to be suggested according to skills and physical reactions of individuals. We consider it an essential initial part in a world, the prevention one, of young people training of the proposed age and also beyond, which often, in our opinion, is left too much to chance. It also highlights the possibility of using the tool on elderly subjects with different problems such as disabilities or with different types of trauma and the device's medical assistance function (already validated at a medical level) has also been underlined as a valid alternative to instruments, currently in use, for cardiac monitoring (see Cardiac Holter) for their accuracy, fit and comfort. It should also be noted that the insertion of additional sensors aimed at assessing the ventilatory capacity is already in an advanced stage of study by the manufacturers, which will make the instrument even more complete in both medical and sports fields and its scientific evaluation.

Author Contributions:

Conceptualization: Izzo R., Luzi A.
Methodology: Izzo R., Luzi A., Hosseini C.
Validation: Izzo R., Cejudo A., Giovannelli M.
Formal analysis: Giovannelli M., Luzi A.
Investigation: Materazzo P., Izzo R., Hosseini C.
Data curation: Izzo R., Luzi A., Giovannelli M.
Statistical analysis: Cejudo A., Izzo R.
Writing, original draft preparation: Izzo R., Hosseini C.
Writing, review and editing: Izzo R., Luzi A., Giovannelli

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