Ergonomic Design for Young Users of Mobile Phones

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ABSTRACT

Children and adolescents increasingly use mobile phones worldwide. The *Report Information and Communications for Development 2012* shows that between 2000 and 2012 the world-wide use of mobile phones has grown from 1 to about 6 billion, resulting in a mobile revolution that is changing our lifestyles. After less than forty years, mobile phones, initially complex, heavy and expensive have become light, handy, economic, visually attractive and multifunctional. These technological and aesthetic improvements allowed high usability for all, especially for children. The *physical, cognitive* and *social ergonomic* characteristics of mobile phones for younger users need to be considered in order to ensure their wellbeing: *physical ergonomics* implies for example the prevention of awkward postures, musculoskeletal disorders, eye sight and hearing overload, electromagnetic fields exposure; *cognitive ergonomics* includes the prevention of dual tasks (such as texting while driving/walking), over connection, addiction and abuse; *social ergonomics* might prevent cyberbullism, sex messaging, self and other aggressive and violent behavior. As an example of precaution, this paper discusses how different countries have started education campaigns for the safe use of mobile phones among children, by minimizing radiofrequency exposures, according to international recommendations and the precautionary principles.

Keywords: children, adolescents, mobile phone, ergonomics

INTRODUCTION

The advent and spread of mobile networks and mobile phones have been a technological and social revolution since the early nineties. The world's first mobile phone call was made on April 3, 1973, when Martin Cooper, a senior engineer at Motorola, called a rival telecommunications company. The Cooper phone weighed 1 kg, allowed 30 minutes of talk-time and required 10 hours to be recharged. Ten years later, commercial mobile phone offered 30 minutes of talk-time and could store 30 phone numbers. In early nineties, mobile devices gradually were starting to appear in the hands of average consumers for the first time. After less than forty years, mobile phones, initially complex, heavy and expensive, have become light, handy, economic, visually attractive, multifunctional. Nowadays smartphones represent the last technological improvement with more advanced computing capability and connectivity than basic cell phones. Smartphones typically combine the features of basic mobile phone with computer functions such as touchscreen, web browsing, Wi-Fi, applications and accessories, document editing together with personal digital assistant (PDA), media player, digital camera, global positioning system (GPS), etc (http://en.wikipedia.org).

Mobiles are arguably the most ubiquitous modern technology, even in developing countries where the development model often gives precedence to mobile phones rather than to electricity or even clean drinking water. Between 2000 and 2012, the number of mobile phones in use worldwide grew from fewer than 1 billion to around 6 billion. While 128 years elapsed before fixed telephone lines reached 1 billion users, mobile networks achieved this milestone in just over two decades (Information and Communications for Development 2012). This means that three-quarters of the world's inhabitants now have access to a mobile phone. Innovation in the manufacture of mobile handset, giving more memory, faster processing power, higher performance, more affordable broadband networks and services, produces a huge transformation throughout societies. High-speed networks, social networking, online activities, are changing the ways of interindividual communication.

As known from ergonomics, usability, efficiency and efficacy of product use, is the major determinant of user satisfaction. Aesthetics too play an important role in product and system design, influencing user performance and perceived usability, especially among children and adolescents (aged 14-17) (Sonderegger and Sauer, 2010).

MOBILE PHONE USE AMONG CHILDREN AND ADOLESCENTS AROUND THE WORLD

In the United States of America (USA), 78 % of teenager have a cell phone and almost half (47%) of them own smartphones. Short messages texting (sms) dominate young adolescents' communication choices and their use of cell-phones, as a way to develop and maintain social interactions, is growing (Redmayne, 2013). The median number of texts sent on a typical day by adolescents (12-17 year-olds) rose from 50 in 2009 to 60 in 2011. Overall, 75% text mainly older teenagers (14-17 year-olds). Girls are the most enthusiastic texters, with a median of 100 texts a day in 2011, compared with 50 for boys of the same age. Daily communication includes phone calling by cell phone (39%), face-to-face socializing outside of school (35%), social network site messaging (29%), instant messaging (22%), and e-mailing (6%), talking on landlines (19%) (Lenhart, 2012).

In Germany, a study found that 35% of 9–10 year-olds from 34 primary schools owned a cell phone by late 2002 (Böhler and Schüz, 2004). Overall, 6 % of children used a cellular telephone for making calls at least once a day and used it several times a week, 45% used it only once in a while, 42% had never used it. The probability of owning a cell phone among children was associated with older age, being male, having no siblings, more time spent watching TV and playing computer games, being picked up by parents from school by car (instead of walking or cycling) and going to bed late.

A population-based study to assess ownership and use of mobile phones and cordless phones among Swedish children aged 7-14 years reports that 79% of the respondents reported mobile phone access, and 27% of them talked for 2 minutes or more per day. Of those who reported mobile phone access, only 6% reported use of hands-free equipment. Use of cordless phones was reported by 84% of the respondents and 38% of them talked for 5 minutes or more per day. Girls generally reported more frequent use than boys (Söderqvist et al., 2007).

In early 2007, 96 % of Spanish students aged 13–20 years owned a cell phone, 81% had one, and 16% had two or more, 55% took it to school and 46% kept it on during class, 42% used it intensively (Sánchez-Martínez and Otero, 2009). A more recent study found that 47% of teenagers at high school use mobile phone without parental control, 46% owned one before 12 years old, girls use it for social relationships and boys for playing, 36% use it for three or more hours a week and their use decreases with age (Muñoz-Miralles et al., 2014).

A 2007 Hungarian study showed that in this country too mobile phone ownership and regular use was highly prevalent among school children. Seventy-six per cent owned a mobile phone; 24% used it daily to make phone calls and an additional 33% for phone calls at least several times per week, 5% sent text messages daily and 24% sent text messages at least several times per week (Mezei et al., 2007).

In Iran, only 31% of the students use mobile phones. The average daily time of using mobile phones in talk mode was 7.08±21.42 minutes. Ownership among boys was significantly higher than the girls, and boys used their mobile phones more frequently (Mortazavi et al., 2011).

In Italy, according to the National Statistics Bureau report *"Daily Life in Childhood, 2011"* children and teenagers are increasingly using new technologies (http://www.istat.it). The use of mobile phones grew nearly doubling between 11-17 year olds (from 56% in 2000 to 93% in 2011). The percentage of 11-17 year olds who use mobile phones only for making phone calls decreased from 20 % to 4%. The largest growth in cell phone use occurred among the youngest. The proportion of children between 11 and 13 years using the phone passed from 35 % to 86%, while, for those between 14 and 17 years, from 70% to 98%. In 2011, 67% of children and adolescents aged 6-17 years use the mobile phone and 56% have owned one (the share of females, 58%, is slightly higher than that of males, 55%). The phone is used for making phone calls (93%), sending/receiving messages (83%). Over half of the children/adolescents between 6 and 17 years old play with the phone, change ringtones (48%), use the phone book (47%), listen to music (47%), make/receive photos (42%).

A survey was conducted in Italian schools involving approximately 4,000 students and their parents in order to "listen" to their needs, their concerns, their desires towards communication (*Minori e telefonia mobile, University of Florence, 2007*). The sample was equally divided by gender. Only 5 % of respondents do not have a mobile phone, or use one of a family. In primary school 80% of children have their own cell phone. The age at which they are given the first mobile phone is declining significantly: some have even received the first phone at the age of 4! Approximately 50% of teen-agers say they use the phone more than one hour a day, while more than 70% of the parents stated that their children use the phone less than one hour a day. They also stated that cell phone use is important in their life relationships, particularly to make new friends (32% of boys versus 25% of girls) or to maintain existing relationships (50%) especially among girls. Half of the parents allowed their children/adolescents to have a cell phone for “safety reasons” and 30% in order to communicate at any time. Time spent on a cell phone increased proportionally with age.

Another Italian study investigated the daily use of the mobile phones among children and adolescents, by administering questionnaires to subjects belonging to two age groups: 7-11 years, 12 -18 years (*Indagine conoscitiva sulla condizione dell’infanzia e dell’adolescenza in Italia 2012*). The results show that 35% devotes up to one hour per day, 42% do not use it at all, 5% use it for more than four hours per day and 4% from two to four hours and 5% for more than 4 hours. Forty three percent of 10-11 year olds use mobile phone up to one hour per day. Time of use increases with increasing age: 13% of children two to four hours a day, among 12-15 year olds more than 4 hours per day (32%) versus 54 % of 16-18 years-old.

Australia is a country where mobile phones have spread in the population very early and youths are the most prolific users. In April 2012, 818.500 children-adolescents aged 5 to 14 years (29%) had a mobile phone (Australian Bureau of Statistics). The proportion of girls with mobile phones (31%) was higher than boys (28%), and the likelihood of having a mobile phone increased with age, with 2% of children aged between 5 and 8 years up to 22% of 9 to 11 year olds and 73% of 12 to 14 year olds. A higher proportion of children born overseas had a mobile phone (35%) compared with those born in Australia (29%), and a higher proportion of children from one-parent families had a mobile phone (35%) compared with those in couple families (28%).

THE ROLE OF ERGONOMICS IN THE DESIGN OF MOBILE PHONE USE AMONG ADOLESCENTS

Today’s children and adolescents have grown up with cell phones, and subsequently with smartphones; this equipment is therefore an integral part of their everyday lives. Young users employ this tool not only to keep in touch with relatives and friends but also as a source of entertainment, due to service providers’ offer of games, pictures or sounds, chat rooms, text messaging and social networks. Research has revealed that the mobile phone is, for children and adolescents, a medium which permits communication without the surveillance of parents, families and teachers (Davie et al., 2004). The type of exposure is also different from that of adults, with increased involvement of eyes, hands, abdomen and brain. The long term health consequences of these habits in the life of children are difficult to predict. In this light, some scientists have suggested that the use of mobile phones among children should be restricted in groups of special needs (Mortazavi et al., 2011).

In spite of rapid worldwide increase in mobile phone use and public concerns about potential negative health effects, little is known about patterns of mobile phone ownership and use in the general population and among children in particular (Mezei et al., 2007).

As shown above, children and adolescents are likely to accumulate many years of exposure to mobile phone during their lives and it is very important to examine how ergonomic design can prevent risks for their future health. In order to ensure children's wellbeing, new technologies of cell phones can be considered in terms of *physical ergonomics*, exposure of their body, *cognitive ergonomics*, exposure of their minds and emotions, *social ergonomics*, exposure to new relationships. The main literature concerning *physical*, *cognitive* and *social* effects among adolescents using mobile phones has been collected and analyzed below for the purpose of using the most important findings in order to propose a new ergonomic design concept.

PHYSICAL ERGONOMICS

Musculoskeletal disorders. Recent literature investigated musculoskeletal symptoms among young users of mobile phones (Gustafsson et al., 2011). These symptoms are mainly due to musculoskeletal disorders of the upper extremity, upper back and neck, flexed neck, right/left hand pain. The typical young mobile phone user sends and receives more text messages than phone calls in unnatural posture. The use of the thumb while texting, typically creates pain at the base or in the muscles of the thumb or wrist. The thumbs are not made for repetitive tasks in such a small device area (http://physioadvisor.com). "*Blackberry thumb*" has been coined by medical professionals to describe this phenomenon (O'Sullivan, 2013). In a population of university Canadian students, 84% reported pain in at least one body part. Right hand pain was most common at the base of the thumb. Significant associations found included time spent Internet browsing and pain in the base of the right thumb (odds ratio 2.21, 95% confidence interval 1.02-4.78), and total time spent using a mobile device and pain in the right shoulder (2.55, 1.25-5.21) and neck (2.72, 1.24-5.96) (Berolo et al., 2011).

A Swedish study found that postures (sitting or standing) and the type of mobile phone task (holding the phone versus texting) affected muscle activity and thumb positions. Females compared to males had higher muscle activity in the extensor digitorum and the abductor pollicis longus when entering sms messages and tended to have greater thumb abduction, higher thumb movement velocities and fewer pauses in the thumb movements. Subjects with symptoms had lower muscle activity levels in the abductor pollicis longus and tended to have higher thumb movement velocities and fewer pauses in the thumb movements compared to those without symptoms (Gustafsson et al., 2010).

Gold et al. observed subjects with flexed neck (91%), and a non-neutral typing-side wrist (90%). A greater proportion of males had protracted shoulders while a greater proportion of females had a typing-side inner elbow angle of <90°, while 46% of subjects typed with both thumbs (two hands holding the mobile device). Just over one-third typed with their right thumb (right hand holding the mobile device) (Gold et al, 2012).

A recent Finnish study evaluated risks related to awkward postures and use of mobile phones. Finland was the first country with early high diffusion of mobile phones. The study reported that users very often experienced physical symptoms in the neck (aches, pain or numbness). The users, who very often had symptoms in the neck, often had also other symptoms (e.g. exhaustion at work) (Korpinen et al., 2013).

Some healthy posture and ergonomic tips for using a mobile device include: alternate between using thumbs and other fingers to type; if using thumbs to type, use the pad of thumb as opposed to the tip of the thumb, as this can create an awkward bent position which can lead to potential injury; keep wrists relaxed and as straight as possible; maintain an upright spinal posture when texting; try to maintain the phone at chest, chin or eye level to minimize the bend in neck and to maintain optimal posture: if the phone is below eye level, look down with eyes rather than using neck; avoid using the phone to one side body with the neck rotated (http://physioadvisor.com).

Hearing loss. Sudan et al. performed the first large-scale epidemiologic study to investigate the association between cell phone use and hearing loss among children (Sudan et al., 2013). Detailed interviews were conducted during pregnancy and when the children were 6, 18 months and 7 years of age. Weak association was observed between cell phone use and hearing loss among 7 year-olds. Khorseva et al. observed changes in the parameters of the simple auditory-motor response in children users of mobile communication in a longitudinal study (Khorseva et al., 2012). Velayutham et al. investigated by a blinded study, high frequency hearing (above 8 kHz) loss among prolonged

mobile phone young users (mean age 27) using audiometric measurements. Chronic usage mobile phone revealed high frequency hearing loss in the dominant ear (mobile phone used) compared to the non dominant ear (Velayutham et al., 2014). Long-term and intensive mobile phone use may also cause inner ear damage, particularly with an increase in the duration of mobile phone use, excessive use and age more than 30 years (Panda et al., 2010).
Eye strain. Regarding the use of mobile phone, blurring of vision, redness of the eyes or irritation, dry eyes, vision disturbance, secretion of the eyes, inflammation in the eyes, and lachrymation of the eyes have been extensively studied (Balik et al., 2005). A significant increase in blurring of vision was reported by young university students users of mobile phone possession >2 years compared to users of mobile phone possession <2 years. In users of mobile phones, women significantly complained more often of inflammation in the eyes than men (Küçer, 2008). Small text and bright screens can strain mobile phone users' eyes; since tablet computers, smartphones, and other hand-held devices are designed for reading at close range, users' eyes must constantly refocus and reposition to process the graphics and text on screen (Bababekova et al., 2011).

Some of the ways to prevent digital eye strain include reducing glare, cleaning the screen, dimming the surrounding lighting that is competing with the device's screen, keeping adequate distance between eyes and the screen, and increasing text size. Users are also advised to take breaks from looking at the screen, and follow the "20-20-20" rule: take a 20-second break every 20 minutes using an electronic device and look at something 20 feet away (Southuniversity.edu).

Skin dermatitis. Cellular phone and/or accessory may produce dermatites among adolescents mainly due to nickel or chromate (Berk et al., 2011). Risk of melanoma and skin cancer due to radiation exposure have not been confirmed (Poulsen et al., 2013), (Inskip et al., 2003).

Electromagnetic fields. Regarding the exposure to electromagnetic fields emitted by mobile phones, it is necessary to emphasize that, from the physiological point of view, children are not little adults. Their brain continues to grow, not only by the increase in number of neurons, but also by continuous changes in configurations and connections, blood brain barrier included (Byun et al., 2013). Children's brain grows rapidly until the age of 3 and reaches adult size after age 14, with some gender differences (Wiart et al., 2007). In addition, children's brain has a higher content of fluid, the skull is thinner and its thickness continues to increase until the age of 18 (Martens, 2005). Recent studies detail age dependent of tissues dielectric properties, conductivity and permittivity: while dielectric properties of gray matter do not change with age, other tissues such as white matter and spinal cord vary significantly (Davis et al., 2013). High resolution computerized models, based on real human imaging data, suggest that higher conductivity and permittivity in children's brain tissues, together with their thinner skulls and smaller heads, lead to higher Specific Absorption Rate (SAR) when compared to adults (Davis et. al, 2013), (Gandhi et al., 2012). Effects on other body organs (for ex. effects on the fetus) have also been studied. Another relevant health issue is the fertility implications of adolescents carrying the cell phone switched-on (>10 h/day) and in-pocket use. Redmayne et al. suggest this may impair future fertility and/or reproductive integrity (Redmayne, 2013).

Studies have examined the relationship between duration and intensity of wireless phone use and several types of brain tumors. The most consistently found risks appear to be from intensive use over a few years, extensive use over ten or more years, use predominantly on the side on which the tumor appears (adult studies) and living rurally. There have been only two publications involving people younger than 20 years. One of these found a consistently greater risk for those whose first use of wireless phones was before the age of 20 (Redmayne, 2013). The other is the case-control study known as the "CEFALO" conducted in collaboration among researchers from Denmark, Sweden, Norwegian and Switzerland (Aydin et al., 2011). Exposure to mobile phones of 352 children and adolescents (aged 7-19) suffering from brain cancer in the years 2004-2008 was compared with that of a similar group of 646 controls of the same age and sex, selected randomly from the population in the same geographical area. The exposure was recorded for both groups through interviews of the subjects and their parents and, for a subsample, through the records of the telephone company. The estimated relative risk for "regular users" (all subjects who had an average of at least one call per week for at least 6 months, based on their self reported amount of phone use were classified as regular users of mobile phones) was 1.36 (95% Cl=0.92-2.02) not significantly higher than non-users. Users of at least five years have no higher risk than controls (OR=1.26; 95% Cl=0.70-2.28). For the subset of subjects for whom data were available mobile phone registers (only a third of cases and controls), results show a significant increase in risk (OR=2.15 95% Cl=1.07-4.29) for those who used mobile phones for more than 2.8 years. The increase however was not significant for those who have done a greater amount of use (cumulative hours of use). Neither a higher risk has been found according to the ipsilateral mobile phone use of the head and tumor location. In conclusion, the authors state that "the absence of a relationship between exposure and response (disease), or in terms of the degree of exposure to mobile phone or in relation to the location of the tumor and part of the head exposed (right or left)

does not support the hypothesis of a causal relationship between cell phone use and brain cancer among children and adolescents". The study has drawn criticism in relation to its statistical power and in the classification of the "exposed" (Söderqvist et al., 2011). The majority of researches on the subject also presents other methodological limitations (eg, uncertainty about the degree and duration of exposure, selection of cases, etc..). New epidemiological prospective cohort longitudinal studies to evaluate health effects of prolonged exposure among children need to be conducted. Children's tumors incidence trends of cancer registries should be followed carefully for all cancers (not only brain), because children tend to develop new habits in using cell phones.

COGNITIVE ERGONOMICS

Cognitive symptoms. Several recent studies have examined possible effects of cell phones on children's cognitive functions and behavior, revealing that health education is needed to promote correct and effective use among adolescents. A Spanish study investigated adolescents (aged 13 to 20) depressive symptoms, social isolation, drug and alcohol use, school failure, and cell phone dependence with intensive cell phone use (Sánchez-Martínez and Otero, 2009). The estimated prevalence of cell phone dependence was 20% (26% in girls, 13% in boys**)**. Intensive cell phone use was associated with female sex, rural school location, good family economy, smoking tobacco, excessive alcohol consumption, depression, cell phone dependence, and school failure.

An Iranian study among elementary and high school students found a statistically significant association between the time mobile phones were used in talk mode and the number of monthly self-reported symptoms such as headaches, vertigo, sleeping disorders**.** The findings confirm the higher vulnerability of children in exhibiting symptoms in association with using mobile phones (Mortazavi et al., 2011). An Australian study found effects on reaction time to stimulus and on memory performance among 11 to 14 year olds (Abramson et al., 2009). A more recent Russian study also showed effects on memory capacity and efficiency and sense of fatigue among very young users aged 7-12 (Khorseva et al., 2011).

Researchers at the University of Melbourne have undertaken a case-control study in children between 11 and 14 to assess, through computerized psychometric tests, impairment of cognitive function (Abramson et al., 2009). Students with highest use (both as sms and voice calls), had a reaction time to stimuli shorter and also a worse mnemonic performance. The profile of the young user emerged as an "impulsive" child (fast but inaccurate). However, a more "impulsive child" may represent a bias of selection among those who claim and receive a phone from their parents.

In Scandinavian countries mobile phones are very popular among children. Researchers have used Danish national birth cohort data from 1996 to 2002 which included 41,000 pregnant mothers. Children were followed until the age of seven. Development indicators to identify any psychophysiology delay (motor, language and cognitive) were examined in the first follow up at the age of 6 and 18 months. A total of 5% of all children presented at least one of these delays in their development but no differences were found between babies with mothers who used phones during pregnancy and those who did not (Divan et al., 2011).

Altered behaviour. Byun et al. investigated the association between mobile phone use and symptoms of Attention Deficit Hyperactivity Disorder (ADHD) considering the modifying effect of lead exposure. A total of 2,422 children at 27 elementary schools in 10 Korean cities were examined by a questionnaire for parents about mobile phone use. The results suggest that "simultaneous exposure to relatively high lead and mobile phone use was associated with increased ADHD symptom risk, although possible reverse causality could not be ruled out" (Byun et al., 2013).
Sudan et al investigated associations between headaches on 52,680 children and both prenatal and postnatal cell phone exposures using the Danish National Birth Cohort between 1996 and 2002. When children reached age 7 year-olds, mothers completed a questionnaire regarding child's health in terms of behaviors and exposures. Children with cell phone exposure had higher odds ratio of migraines and headache-related symptoms than children with no exposure, although potential confounding and misclassification have to be considered (Sudan et al., 2012).

Cell phones are a relatively novel and evolving technology; while the potential benefits of this technology continue to emerge, so do the potential psychosocial risks. One psychosocial risk is user's stress, which appears to be related to feeling compelled to promptly respond to cell-phone activity in order to maintain spontaneity and access with

others. Other potential psychosocial risks include disruptions in sleep and overuse, particularly among adolescents. With regard to the latter phenomenon, the boundaries among overuse, misuse, dependence, and addiction are not scientifically clear (Sansone et al., 2013).

Addiction/dependence. Mobile phones use involves a risk of abuse and addictive behavior, especially for young people (Halayem et al., 2010). Pedrero Pérez et al review the state of scientific knowledge about cell phone addiction/abuse. Self-attribution of cell phone addiction exceeds the prevalence estimated in the studies. The personality trait most consistently associated with addiction is low self-esteem. Women with low self-esteem are the most vulnerable group, though extraversion is also associated with more intense use (Pedrero Pérez et al., 2012).
Walsh et al report a qualitative exploration of psychological factors related to mobile phone use amongst Australian youth. Thirty-two participants, aged between 16 and 24 years, took part in focus group discussion. Thematic data analysis focused on identifying the psychological benefits arising from mobile phone use and whether mobile phone addiction was occurring amongst this group. Mobile phone use was believed to provide numerous benefits to users and is an intrinsic part of most young people's lives. Some young people however are extremely attached to their mobile phone with symptoms of behavioral addiction (Walsh et al., 2008).

Thus the scientific evidence suggests several psychological health problems in relation to mobile phone use, but vagueness in definitions of the concepts of “abuse” and “addiction” and the poor quality of the studies make it difficult to generalize the results (Pedrero Pérez et al., 2012).

Dual tasks. Safety issues in use of mobile phones among adolescents (15 to 20 years old) are connected to their use while performing a secondary task, such as driving while dialing or talking or listening to music or sending or receiving text messages (texting while driving TWD). All these activities involve a major source of danger. Estimates based on cell-phone records indicate that cell-phone use among all drivers increases the risk of a crash by a factor of 4 (Klauer et al., 2014). Olsen et al. used data from the United States Centers for Disease Control and Prevention's 2011 National Youth Risk Behavior Survey, to assess TWD among 8,505 students aged ≥16 years representative of US high school students. The results show that nearly half of these students report TWD on the road during the past 30 days, with an elevated risk for a crash-related injury (Olsen et al., 2013).

Typing and reading text on a mobile phone may modify walking as a result of the increased cognitive demand placed on working memory and executive control during performance of dual tasks, decreased availability of visual information of surroundings, or modified physical/mechanical demands associated with manipulation of the phone (e.g. requirement to maintain a stable relationship between eyes and phone in the hands). Evaluation of gait performance (>18-29 males) revealed that individuals walk slower, demonstrate greater absolute medial-lateral step deviation, increase rotation range of motion (ROM) of the head with respect to the global reference frame, walk with a flexed head position, reduce neck ROM, and move the thorax and head more in-phase with reduced phase variability, during texting and reading while walking unconstrained (Schabrun et al., 2014).

SOCIAL ERGONOMICS

Cyberbullism. Studies of cell phone use in the 21st century report that well over 50 % of adolescents use them and that text messaging is the communication mode of choice. Cell phones and smartphones are changing relationships among adolescents and children in quality and quantity, because mobile multifunctional technologies expose them continuously to on line social networks. Young people are therefore always connected with others, with potential risks to be exposed to verbal and non verbal aggressions from known and unknown sources. In Italy *Save the children*, a no profit-organization, has conducted a survey (n. 810 aged 12-17) on cyberbullism (Save the children-IPSOS, 2013) and previously a survey on safer internet (2012) in order to better explain the phenomenon. Forty per cent of the sample was touched by cyberbullism and 5% declare a regular experience of it. Studies show a significant percentage of adolescents send and receive sex messaging, both text and images (Korchmaros et al., 2013), (Korenis and Billick, 2013). Risks of cyberbullying, contact with strangers, sexual messaging ('sexting') and pornography generally affect fewer than one in five adolescents. Longitudinal studies reveal a range of adverse emotional and psychosocial consequences. Some children are more vulnerable than others due to several risk factors: personality factors (sensation-seeking, low self-esteem, psychological difficulties), social factors (lack of parental support, peer norms) and digital factors (online practices, digital skills, specific online sites) (Livingstone and Smith, 2014).

Aggressive behavior. Psychiatrists are also studying the increased risks of aggressive behavior among adolescents. A study explored the association between problematic cellular phone user and suicidal ideation and attempts among adolescents. Family function and depression influenced this association. The rates of suicidal ideation were 23% in problematic user and 12 % in no problematic ones. The rates of suicidal attempts in both groups were 14% and 5% respectively (Wang et al., 2014). A study on north American girls (aged 8-12) showed how negative social well-being was positively associated with the use of phone and online communication. Conversely, face-to-face communication was strongly associated with positive social well-being (Pea et al., 2012).

The challenges are to examine the relations among different risks and design effective interventions identifying protective factors.

PRECAUTIONARY PRINCIPLE IN THE ERGONOMIC DESIGN: THE CASE OF EXPOSURE TO CELL PHONE ELECTROMAGNETIC FIELDS

Internationally, concerns have been voiced at governmental level and by scientists regarding possible adverse health outcomes from frequent wireless phone use by young people. Recommendations for a precautionary approach for children to minimize their use of cell phones are common (Redmayne, 2013).

On May 21, 2011, a committee of 30 invited scientists from 15 different countries working on behalf of the International Agency for Research on Cancer (IARC) of the World Health Organization reviewed key studies on the topic and characterized exposure to radiofrequency radiation associated with mobile phone use as Group 2B carcinogen, i.e. possibly carcinogenic to humans (IARC Monograph, 2011). This is the same category as the pesticide DDT, gasoline engine exhaust, burning coal, dry cleaning chemicals, and jet fuel compounds that are subject to serious regulation and control around the world today (Davis et al., 2013). Based on these findings, the Council of Europe issued a resolution in May 2011 for Member States of the Council of Europe (Resolution 1815 of the Parliamentary Assembly of the Council of Europe 27 May 2011), which recommended the application of the ALARA principle (As Low As Reasonably Achievable, so low as reasonably achievable) and the Precautionary Principle addressed particularly to children (Assembly.coe). The precautionary principle or precautionary approach states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking an action. The principle is used by policy makers to justify discretionary decisions in situations where there is the possibility of harm from taking a particular course or making a certain decision when extensive scientific knowledge on the matter is lacking. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protective measures can be relaxed only if further scientific findings provide sound evidence that no harm will result (Talamanca et al., 2012).
The Assembly recommends to the member states of the Council of Europe on the potential dangers of electromagnetic fields and adviced (Assembly.coe):

a) to advice in particular the protection of children; b) to reduce exposure of children and young people who seem to be the more at risk of head tumors; c) to provide information to undertake awareness-raising campaigns on the risks of potentially harmful long-term biological effects on the environment and on human health, especially targeting children, teenagers and young people of reproductive age; d) to introduce clear labeling indicating the presence of microwaves or electromagnetic fields, the transmitting power or the SAR of the devices and any health risks connected with their use; e) to develop within different ministries (education, environment and health) targeted information campaigns aimed at teachers, parents and children to alert them to the specific risks of early, inappropriate and prolonged use of mobiles and other devices emitting microwaves; f) for children in general, and particularly in schools and classrooms, strictly regulate the use of mobile phones on school premises; g) to increase public funding of independent research to evaluate health risks.

On the basis of these recommendations, some countries have started an education campaign for the safe use of mobile phones among children (http://www.mobilewise.org): in the UK, public guidance on mobile phone use is led by the Health Protection Agency (HPA), which monitors and reviews research internationally. HPA's most recent

guidance reiterates the advice, first issued in 2000, that children should limit their use of mobile phones. This advice continues to be made on the basis that scientific knowledge in this area is limited and that a question mark remains over long-term health risks. In the USA, San Francisco city government recently approved regulations requiring retailers to give all customers a government leaflet outlining safety steps regarding children and mobile phone use. Similar proposals have been put forward in Maine and Pennsylvania. In France, mobile phones are banned from primary schools, and operators must offer handsets that allow only text messages, all phones must be supplied with a headset, sale to children under 6 is prohibited and advertising targeted at children is banned. The government has commenced a safety information program through its National Institute for Prevention and Health Education. The Basque Parliament supported the Council of Europe's resolution and urged promotion of campaigns against excessive use of mobile phones among children. The Russian National Committee on Non-Ionizing Radiation Protection has recommended shortening calls, use of hands-free devices, warning statements on phones, education in schools, limits on use by children and a ban on advertising to children. The Canadian public health service has issued new cautionary guidelines on children's mobile phone use; they include practical advice for those under-18 on how to reduce exposure to radiation by texting rather than calling, using hands-free devices and limiting the length of voice calls.

Recently, specific interventions have been recommended by the American Cancer Society and the Environmental Working Group for minimizing radio frequency exposure especially for children (Rosenberg, 2013). Their suggestions include the following precautions: 1. use a wired headset or speakerphone, because the antenna is the major source of radiation frequency; keep away from head. 2. purchase a cell phone with a lower SAR; cell phone companies are required to post SARs on insert literature. Parents can find information from manufacturers on line. 3. limit children's use of cell phones until they are 16 years old; parents and schools can limit the time periods children may use cell phones by removing cell phones and monitoring minutes used. 4. teach children to use both ears daily and not to press close to the ear until connection is made; this reduces exposure to the same side and reduces accumulation to tissue. 5. parents might check areas where the signal is weak and not allow children to use cell phones in these areas; weak areas require increased energy from source to reach the antenna; thus, higher radiation exposure.

CONCLUSIONS

Mobile phone is a new technology and there is still little evidence about long-term health effects, especially among children and adolescents. Compared to adults, however, children do in fact need to be considered at higher potential physical, cognitive and social risks, depending on their phase of growing. If adults are advised to minimize their exposure, this is even more justified for children. Even in the absence of scientific certainty on the issue of children's risks, effective prevention is needed before the damage. How ergonomics can play a role on this issue? First of all, it is important to create a major interest on children and adolescents ergonomics. The traditional interdisciplinary view of ergonomics needs to be more oriented towards children and adolescents wellbeing together with the contribution of other professionals (such as: pedagogist, pediatrician, psychiatrist, etc.). The interdisciplinary view could open a debate on if, when and how children/adolescents might have access to mobile devices, hypothesizing even to ban them under a certain age (ex. in France this age is <12). Gender differences in mobile phones use have been also found especially on some specific aspects that should be more studied (ex. texting vs phone calls, relationships vs playing, maintaining friends vs new friends, more intensive use, less self esteem). The precautionary principle to minimize electromagnetic fields exposure should be considered together with other physical, cognitive an social exposures. Appropriate information campaigns to raise awareness to a more careful and responsible use of mobile phones by adolescents should be planned in all countries, both those economically developed and developing. Mobile phones ergonomics, applied up to now by industry to promote the diffusion of this technology, should now be used to prevent negative health effects in the future of new generations.

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