HF/Ergonomics of Assistive Technology

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Abstract An assistive device is designed to accommodate the special needs of disability that can help people with physical, mental or cognitive challenges go through their day-to-day activities with less difficulty. An assistive device usually provide alternatives to functional limitations imposed by the client's disorder, and thereby minimising rehabilitation costs. It is therefore important to know about how assistive technology will function in all the possible aspects of such disabilities and impairments. When designing a technical device, particularly in conjunction with the target user group, ergonomic issues are therefore important to find out the extent to which an assistive device is convenient or not, and to check the quality performance of assistive technology. Since the question of the match or mismatch of an assistive device and a disabled person requires much attention, it is therefore suggested that paying attention on how an assistive device be ergonomically designed and developed is important. Ergonomic applications are to be applied for increasing motivation of prospective customers through innovative performance of AT. The authors believe that there are opportunities in ergonomic applications to manufacture an assistive device as unique, cost saving, and allows less exertation and reduces energy consumption when it is used. Hence this paper highlights human factors and/or ergonomics consideration in the process of design and development of assistive devices synchronising with gerontechnological research and development aiming to emphasise user's requirement. *J Physiol Anthropol* 20 (3): 187-197, 2001 <http://www.jstage.jst.go.jp/en/>

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Introduction

With the influence of technical innovation, our society is changing rapidly, from an ultra-modern to a digital life. Various types of assistive technology (AT) are advertised or marketed to be attractive to a particular use and many of our disabled friends and senior citizens are enjoying a sophisticated life using AT. Assistive devices also enhance disabled people's mobility and communication and help them to maintain independent living. AT is a certain form of system or sophisticated devices, which are generally used for assisting the people with disabilities. Electric wheel chair, electric rams, or automatic lifts, remote control aids, auto alarm systems, door intercom, auto lightening, cordless telephones or answering machines or computer assisted communication system are introduced to control domestic appliances [Figure 1]. Various other systems are also available in the market for the people with special needs in operating televisions or to open radios, videocassette recorders, and hi-fi deck sets, for instance.

It has also been identified that assistive aids are being used in the rehabilitation centres with the growing number of disabled and older people whether many of the devices are not cheap in the market. Many products, tools and services are engineered and marketed by lucrative advertisement. However there are an increasing number of reports about various problems possibly due to the influx of such devices which do not always satisfy all people. Of these products, many of such devices, processes, tools, techniques, and services appraised for special purposes, are found to be inadequate or inappropriate in some respect. AT may not match with the user's requirements, or not always well suited in all environment and circumstances. It has also been well documented that a sophisticated device can easily be troublesome to use perfectly by disabled persons. In many instances, a technical device is a complicated

Fig. 1 An example of multidevised assistive system to operate home appliances.

electronic system that may not be well suited for individual's need. The reason is, the impact on the use of AT and ergonomic consequences is not popular to the some manufacturers. Even, Human factors (HFs) issues are not often taught to the users. There has been little effort in the development of AT by illustrating HFs or ergonomic design methodologies and ergonomics thinking. It is therefore obvious that due to a lack of ergonomics data, many devices or systems do not meet with the users' characteristics. Further, due the complexity of AT, new users can not operate the device easily. The users are perhaps older people or disabled individual, who are often sensitive to operate such types of modern technology. In addition, they are usually less adaptive with many of the newly designed product and tools. Computers, for instances, are not familiar to many of them thus, someone can be afraid of their correct use and operation. Again, if the device does not work well, they could be frustrating to control and manipulate. There is also a lack of information available on both AT and disability which seeks even in modest ways to address the complexity of utilising AT. Finding appropriate devices that are truly assistive for a disabled person remains an arduous task, because there has been difficulty in assessing and evaluating an individual's needs. However much of the inadequacy and inappropriateness could be removed by examining an AT, and to stimulate different approaches and perceptions. While designing and planning of ergonomics of rehabilitation, the methods of ergo-economic studies and research on eco-ergonomics aspects have to be developed through the use of technology prototype testing by the disabled users. Vernon and McClelland (1976) evaluated a prototype bath aid, for instance, that may be useful for solving the mismatching the user's systems. The latest developments in ergonomic trends and practice [www.ergoexpo.com] are therefore helpful for the pre-eminent educational forum for the concerned professionals.

Following the range of an interactive model, Mathews and Seekins (1987) emphasised the ergonomics application. Considering technical, biomedical and

psychosocial aspects of AT, Ahasan and Tanya (1999) illustrated alternative way of designing non-traditional rehabilitation. Kumar (1989; 1992; 1996) noted that rehabilitation engineering is of vital importance for finding new ways of co-operation on user-friendly services. Some tools and devices are evaluated through the cost-benefit analysis (Petäskoski-Hul, 1995; Torrens and Kay, 1995; Huijman and Rutten, 1994; Drummond et al., 1987). It is general that price is an important factor that needs special attention. Indeed, those evaluations do not touch basic criteria of low-cost design that would attract buyer's capability to use such products and tools.

What is a Non-Ergonomic Device?

Non-ergonomically designed products, tools or devices usually result in, or inadequate from a mismatch between the user's characteristics and the environment. An AT that is considered ergonomically inappropriate usually had problems in functionality; quality; usability; and safety problems *Functional problems* may be identified among many of such devices, which do not function or work at all and those, which function poorly. *Quality problems* are usually identified when a device is not suitable for the purpose. *Usability problems* are defined when it is considered non-useful for an environment, system, or of a certain circumstance, or for a particular person. A *safety problem* is particularly recognised when a device is designed to help disabled people results in danger to them.

A non-ergonomic device is one that can affect individual's ability to operate the system in properly, or occurrence of injuries, for instance, without unreasonable behavior. It can be a system with no useful function, or functions poorly in the light of the high incidence of mismatching the system. A non-ergonomic product means that size, shape, colour, weight, dimension, or density is not just right for the people who need it. A device that introduce a safety and health hazard is also a non-ergonomic device, which may not work for all types of disability. A non-ergonomic device is 'unhealthy' when it is not made according to the consideration of user's

physiology, neurology or other aspects of human health.

To reach high shelves, for instance, it can cause an accident, if the stool is made without ergonomics criteria. A non-ergonomic stool, for instance, can be tripped easily when a user needs to lean on this stool as a support to reach something from cupboard. In order to reach the ground and keep out from slipping, the stool should have braking mechanism for use on a slope. It should not be risky or cause an accident, while to sit on the wheeled-stool. In case of a hand rail, for instance, design should be made in such a way that the side-handle will surely help to people with restricted mobility. Some devices or systems may not reasonably be helpful for disabled people because it is not made to work good or function partially. Some other can be incomplete compliance with the user's characteristics. Disabled people's lives may also introduce a problem with health, safety and hygiene. An assistive device is 'non-hygienic' when it can not be recycled easily, or hazardous for the human health and the environment. An ergonomic device or a system is dynamic, efficient, compatible or truly useful for disabled users. Indeed, users' criteria are to be checked before a technical device is delivered, displayed or marketed for the people with special needs. In terms of ergonomic quality of AT, a device is 'safe' when it maintains user-regulation, HF's and/or ergonomics criteria. A device or product is ergonomic when it solves problems about the design and develops usable systems. In this case, the device needs to be set out in a convenient way so that it is not risky to use. A disabled person using a non-ergonomic stick has to balance unaided and operates the stick with two hands, for example, whether an ergonomic stick would probably have the ability or confidence to use it for a secondary function. If an AT is designed inappropriate, then it brings errors, injuries and accidents.

Ergonomic Design and Development

It has become apparent that various types of AT are available in the market but many of them are not designed accurately to accommodate the special needs of disability. Therefore ergonomics of alternative design of AT is of vital importance. Ergonomics of AT means how safely a device can be used, or how to maintain the safe manipulation of a technical system to suit user's anthropometrical, physiological and psychosocial needs. The central concern of ergonomic evaluation together with the end users is a driving force. In order to design a meaningful device that is useful for specific purpose or actual need, both a user's choices and satisfaction need to be enhanced according to the specific features of the disabled users. Philippen (1994) illustrated how design criteria must be met fulfilling the basic need of disabled people. It means that disabled people should be able to manage themselves in daily living activities, while using

an assistive device.

Ergonomic design specification is vital to find a scientific basis that favours improved life of a disabled person. How ergonomic designs could be helpful for special need, Coleman and Pullinger (1993) noted on some aspects of improvement features of disability and ageing process. Ergonomic design is related to the user's satisfaction based on performance specific design that complies with the user's stature and posture. The core requirements of AT use and its operation are to be specified correctly since it deals with various human aspects. Ergonomics application is important in the design and development of AT towards meeting the needs of disabled people. Hence by addressing the actual needs of these people, ergonomics principles are to be followed to enhance the mobility and communication of disabled people.

Ergonomically designed AT, usually, enhance functional requirements that correctly fits with the future application of the users meeting needs of disabled people. User-based analysis were discussed in many papers (Ahasan et al., 2000; Blumkin, 1997; Amaducci et al., 1995; Buhler and Schmidt, 1993; Hermanova, 1991; Ender and Hall, 1990; Mattingly, 1981; Galvin and Phillips, 1960) but none of them touched potential importance of ergonomics for all aspects of disability and rehabilitation. Ergonomics design and development are usually be acceptable to broader range of users, either elderly or handicap children. The user's requirements will be met, when design of an assistive system is ergonomically tested or evaluated on various aspects of disability and ageing. In the early stage of design, ergonomic guidelines (ILO, 1996) and checklists (Pirkel and Babic, 1988) would result in making a better device, which deal with a consumer's involvement. These are also useful to answer the unresolved issues, such as for correct use of a technical system. In this regard, technical assistance and independence of disabled person's life was discussed in many papers (Lin and Yang, 1997; Martin and Raabe, 1997; Scherer, 1991; Chaffin and Andersson 1984).

Ergonomics devices cover all these factors including the infirmities that flow from the fact of impairment, handicap or disability problems. Rehabilitation professionals, psychologists, physiotherapists, social workers, and others should be involved in the development of AT. It is also important to understand the type of disability and the service delivery systems. In this regard, the rehabilitation authority should communicate with manufacturers so that functional characteristics are maintained for AT. There should be a dynamic relationship between AT and the type of disability so that service delivery system is unique and interruption-free. Local climate, environment, housing, transportation and others should be synchronised with the design process. It means that AT should be designed in such a way that it is

environmentally sustainable, easily recyclable and harmless.

Users' Requirement

In many cases, AT may not reasonably be made to work even partially for the adaptation or adjustment of an individual user's environments. It can be particularly poor meeting the users' satisfaction due to the rapid changes in operating systems. An evaluation strategy is therefore needed for clarifying the functional characteristics of AT. Specification of AT is important where user's physiology, anthropometry or anatomy should be considered. Similarly, users' grip strength, holding capacity, postural balance or mobility performances to be considered because AT needs to match their anthropology, physiology and cognitive characteristics. HFs/ergonomics aspects are the basic elements to which the device is convenient to use or not. While considering the question of matching or mismatching the AT, usability issues are thus important. AT will be useful or adaptive as much as possible to a changing situation of rehabilitating disabled people, when a user-based assessment is conducted by the concerned professionals with the collaboration of

manufacturers. Consumer-based criteria are also important because it deals with socio-economic consideration; political, the involvement of professional teamwork. Hence, many HFs engineers emphasise user-usability issues. An ergonomic walking stick (Fig. 2), for instance, could be used for both walk balancing and to pick up small items. Figure 3 shows other example of walking aid that may help balancing and carrying stuffs. An ergonomic device can function quite well not only at such tasks when able-bodied people try it but also when disabled people use it. A user requirement is therefore important not only in the design phase but also in the development phase.

The actual use of AT will help us to know about users' characteristics to identify both negative and positive features of selected appliances regardless of age, gender, culture or type of disability. Since ergonomics is important where unexpected input of mismatching the users' systems is concerned, thus utility and usability of AT can easily be illustrated using some design philosophy to develop ergonomic systems. The authors' approach to usability issues (Fig. 4) can best be useful when the level of success is dictated by the assessment of disability and ageing process.

The value of this approach can also be used to measure

Fig. 2 Examples of walking stick which could be used for both walk balancing and to pick up small items, for instance.

Fig. 3a An example of walking aid that may help balancing.

Fig. 3b An example of walking aid that may help balancing and carrying stuffs.

the usability issues. New ways of co-operation on user-friendly services are needed to adapt to user's need. A user-based analysis has to be evaluated through qualitative research and with empirical studies in designing ergonomics systems. For effective design and development of AT, ergonomic analysis is believed to be prioritised that come up in the everyday use of such tools. In the experiences of long-term users, ergonomic issues are to be prioritised through identifying problems and solutions of the user's requirements. A computer-based tool is also useful in supporting the environmental controls. However such adaptation can vary as each individual's need is different. The interactive model of ergonomic design is illustrated by Winterberg (1995) to enhance disabled user's mobility and independence. Martin and Raabe (1997) expressed concerns for adapted technology considering psychosocial and cognitive suitability. Hobson and Shaw (1987) identified some important aspects of HF/ergonomics for new design strategy of developing AT. Ergonomic principles also enhance new ways of co-operation on user-friendly services. Ergonomic requirement is recognised as important as for operating these modern technologies. User's involvement is important for to adapt users with AT. User-interface behaviour has to be considered in the experiences of long term benefits. Therefore a clear and

Fig. 4 Factors affecting user-usability for successful application of assistive devices.

fairly extensive explanation of using these tools is necessary to see how effectively an AT can match with the rehabilitation objectives.

The Role of Ergonomist

Ergonomists usually deal with problems solutions associated with the use of everyday items or products. These are various types of home appliances, mobility aid, environmental control systems available which help to increase functional mobility of disabled people. However, user-friendly tools are not established in the adaptation to the life of an individual user in many cases. What ergonomists do is intervening and local factors (Fig. 5) for cost-effectiveness of technical devices. They test or assess disability, rehabilitation and ageing process to develop environment-friendly devices. It is evident that functional characteristics of disabled users are, however, can influence the use and operation of AT. Nevertheless, the mode of operation of an AT is to be flexible or changeable.

By considering the interactions between the AT and the disabled user, ergonomists often give feedback on technological innovations. While using a technical system, ergonomists seek to provide benefits to disabled

people in the design of low-cost rehabilitation. Ergonomists also help to improve the quality of rehabilitation by considering the repair and maintenance of AT. Kumar (1998); Ahasan (2000a, b, c, d) and Peterson (1996) emphasised ergonomics criteria with special reference to the alternative design of assistive tools. Dealing with the correct evaluation of AT for independent living, ergonomists assists an individual user with a disability and consider user's comprehension to satisfy the intended users. For particular aspects of disabled people's needs, and with specific difficulties of each individuals, Ahasan (1998) and Gould (1988) illustrated ergonomics consequences, which are supposed to be effective and match with user's comprehension. Fostering the design of a unique device, an ergonomist directly involved in the design and development of AT.

Ergonomists are traditionally non-traditional, and they are HFs experts in both technical and non-technical perspectives to simulate different approaches and perceptions in achieving better physical, mental and social capacities. Ergonomists devised special features of AT considering anthropometrical, psychophysical and cognitive characteristics. By opening new avenues of opportunity for making their everyday life easier,

Fig. 5 A comprehensive model endorsing ergonomics of assistive technology.

ergonomists work together with social workers, physiotherapists, psychologists, communal authorities, and others so that user's right and obligations are sustained according to the technical characteristics of AT. Hence considering both confounding and contributing factors, ergonomists involve with innovative research on developing AT. They also focus on the professionals' involvement collaborating with others in the design and development of AT. Ergonomists/HFs experts encourage a specific consumer voice' considering socio-economical and political issues. In order to monitor poor design or hazardous products or devices, ergonomist do all the best so that there is a minimum level of problems to manipulate the device and maintain its usability. By designing and developing a suitable tool with various facilities, ergonomists can help people's usability issues to fill the gaps between disabilities and abilities. They also belong to the usability engineers who are involved in making plans and launching programs for the suitability and adjustability of AT. To enhance rehabilitation facilities, ergonomists help people with special needs in many ways so that those with disabled people can enjoy and maintain a sophisticated modern life. They also design community-based services co-operating with the concerned professionals.

Ergonomic Interventions

Many assistive devices can cause problems either in fit to the people or use quite easily. Therefore ergonomic interventions introduce as regulations or standards to govern the design, manufacture and marketing of AT. Ergonomic interventions should therefore be addressed by providing a comprehensive review of all types of disabilities organised around research themes. An example of ergonomic intervention is when a device is made in such a way that is truly assistive, and without causing any accident for people who have difficulty reaching down or lifting up, for instance. In order to gain benefit from using such an ergonomic device, vertical height or lateral distance should also be adjusted. To clarify details in interaction with disabled users, ergonomic requirements, while intervention is concerned, for individual's functional assistance, or standards of performances need to be specified whatever environment is. The activities of daily living of disabled people need to be examined in such a way that all tasks are done safe and healthy while using AT. If the match is not a quality one from the viewpoint of the disabled users, then AT will not truly be beneficial for practical use. AT should therefore be modular based, unique, reliable, and prospective not only for disabled people but it should be easily accessible for all of us to all environment and circumstances. If attention is paid to basic ergonomics at the drawing-board stage, then access to common places or

domestic appliances can be enhanced. For ergonomic intervention, the people with special need should decide upon functional specifications of AT. In this regard, Lindkvist (1988) illustrated Swedish experience, while ergonomic interventions are applied for the correct design of AT and disabled or elderly users. More information can be found on ergonomic intervention and design perspectives [<http://ergoweb.com/discussions/ewl.cfm>]. Other websites provide information how ergonomics interventions could be of helpful in product design and development (www.alimed.com). The European Commission's Technology Initiative for Disabled and Elderly People [www.ilo.org/public/english/employment/skills/targets/disability/] is one of the main institutes to deal with ergonomic solutions. Some companies [www.iacindustries.com] are also involved with manufacturing of ergonomic tools, devices and equipment. To meet the growing demand, the Special Needs Research Unit of the University of Northumbria, and the Institute of Consumer Ergonomics in the United Kingdom also published a large-scale survey on AT. The Institute of Consumer Ergonomics at Loughborough University also conducted several studies for evaluation of usability characteristics of home aids and other equipment.

Choice of Assistive Technology

There are various types of AT, those can be used for many purposes. However choice of AT is to be made on the basis of responsiveness and utilisation of a device. In this context, some studies (Galvin and Scherer, 1996; Peterson, 1996) were concerned for selecting appropriate device. The choice of AT should also be based especially why users should decide to accept or reject a device. A proper selection of AT requires biomechanical, anthropometrical, psychophysical or physiological consideration. Shiau et al. (1997) designed a walker device, for instance, that can work effectively for the needs of children with cerebral palsy. Usability issues are of prime importance in the choice of AT, because individual's choice must focus on safe, reliable and efficient use of a technical system. In this regard, Grady et al. (1991) expressed concerns on promoting priority of option through evaluation and assessment of user's characteristics. We should select AT on the basis of client support service rather than technology-support systems. Therefore, AT should be proactive in, and effective of its control systems rather than meeting only the physical and biomechanical specifications. It is unlikely that poor experience with an AT would result in hesitation over further use of a device. The exposition problems are massive in correct fit of AT to a person who really needs it. But it is the substance that should be correct to the correct users. There are so many products in the market

that users many have problems to choose the correct one. They may have no idea what the end product would look like. For correct use of AT, we should emphasise the design of AT on the basis of consumer-responsive rehabilitation. Therefore it is better to select such a device that is truly useful and helpful for disabled people. A well-suited and extendible rule-based device is preferred because it encompasses the actual needs of the disabled people. AT must also be statutory or voluntary as to how and why rehabilitation authority prescribes AT. A better understanding of disability type is of importance, because disabled person's psychosocial, economical and political right has to be maintained. Local factors are also important in the selection of AT, since the device need to be adapt and/or adjusted to the existing environment. The interaction between the individuals delivering a system, and the individuals receiving that system should therefore be considered carefully. However, in assessing the user's preferences and predisposition to the use of particular devices, it is also a matter of time, effort and the individual's choice. Some basic criteria of AT selection are illustrated in Table 1, which can be useful in the decision making process.

Discussion

World statistics show that increase in the number of the people either with partial abilities or disabilities will lead in the future to disturbances in demographic distribution. Hence, WHO's programs (WHO, 1981) on disability prevention and technical rehabilitation has drawn our attention. The activities on applied research with user

involvement are on going, especially with new technology prototype testing and development of AT by many professional groups. However, for intuitive development of appropriate assistance from AT there is still a need for ergonomic consideration. Since the design and planning of environment is rather difficult for adaptations of our disabled friends or elderly relatives. Thus, a continuous support is needed with the collaboration of designers, engineers, architects, social workers, healthcare professionals, and others.

To increase functional capacity and enhancing the mobility of disabled people, AT have to be customised and configured through ergonomics considerations. A clear and fairly extensive explanation must also be considered so that we all understand the importance of ergonomics. While using an AT, the users are to be able to communicate with each other. In this regard, the impact of AT should be evaluated on a case by case basis so that it is safe and reliable. While using assistive devices, user system or environment should be taken into account for well functioning of AT. The needs of disabled people can not be complete without considering physiological, biological, psychosocial, or cognitive suitability. Those should be evaluated to bring disabled people to the level of activities of daily living.

The disabled citizens are often sensitive to operate complex devices and many of them still hesitate or unable to use complex devices. Many of them are not habituated to use or acquainted with complicated devices. Or, simply they do not want to handle sophisticated forms of AT. It is usual that disabled people face many other problems in everyday life. If AT is tailored to suit the

Table 1 Selective criteria of assistive technology (Ahasan et al. 2000)

Aims and tasks	Abilities and/or non-abilities
Have we identified the actual need of assistive tools according to the tasks? What type of assistance he/she is currently getting? What is the easiest and cheapest way to use the devices? Can we change the activities so that he/she does not need any assistance ? Will he/she need such an extra assistance e.g., helper, other support, and additional aid to use an assistive device?	What is the problem? Is it stable or changing? Do we know his/her physical and mental abilities to suggest for a correct device? What are the design criteria required to use the device properly? How does he/she manage daily living or home activities? Is it important to do things as independently as possible? Does the tool, device or system helps him/her to be more independent or dependent?
Situation and circumstances	Types, criteria and preferences
Where (e.g., at home, work or community) will the disabled person use AT? Can the environment support the device? Is the environment physically accessible? Could the environment disrupt the performance of AT, as is possible in the case of an electronic interface? Is the transportation available? Are people available to assist the disabled person if needed? How would the device affect other people in that environment?	What types of devices do the persons prefer? Does the device reflect his/her lifestyle, gender, age, personality or values? Have we considered all types of devices that are available and low-cost? How well do they find an alternative devices work? How much will the device cost? How long is it likely to last? Will it be available and easy to buy? How much will it take to care of? Will it be easy to use, maintain, and be taken care of?

special needs of the intended users, then other problem will be minimised. AT may not thus be suitable for all types of disabilities that might occur in the everyday use of individual's assistance. In the form of quantitative design specifications, it is extremely difficult to tabulate or regulate the necessary findings so that ergonomics application could be of helpful for all of us. Many of us however do not know the disability rights. Even the personnel concerned may not care the elderly rights or disability legislation. However, protecting older people in an ageing world are becoming an increasing concern. Yet many older people's rights are disregarded or violated by their governments and societies. Drawing on fifteen years of work in more than sixty countries, the HelpAge [www.id21.org/static/5aSB1.htm] report documents how the rights and needs of older people are neglected. Their contribution to society is also ignored. Given that the world's population is ageing rapidly, this neglect amounts to an urgent problem— even more urgent in developing countries where many older people, and older women in particular, live in poverty.

In many countries, manufacturers do not maintain ergonomic regulations. Many of them do not know what ergonomics is. In reality, it is also difficult to interpret ergonomic data in terms of errors, injuries and accidents since existing and local resources are limited in many countries to design and develop AT. Also, if an AT does not appear in accident data it does not necessarily imply that they are well designed. It is also understandable that AT may not be useful for many users due to the rapid changes in operating systems. It can be difficult because the validity of information and applicability of different devices has yet to be satisfactorily known to the rehabilitation authority and supplier of the assistive devices. People with partial disabilities are also wary of use and operations of AT. Hence, teaching new skills to the disabled or partially disabled people is perhaps a challenging task. Due to the rapid changes in operating systems, manufacturers can be reluctant to change or launch new products. However rehabilitation authority, sub-contractors or AT suppliers should aware of the importance of AT use, and its operation and manipulation. While using AT by a disable person, possibilities of injuries could be prevented if a suitably designed tool is prescribed. And, therefore ergonomics applications could, and should, be utilised widely to reduce such incidents. Professionals involved from various disciplines are also involved in different ways with the design of AT.

Conclusion

The literature cited in this paper is integrated around the disability research themes, while missing data information on specific research needs in AT. There was

no methodology since this paper is a literature review by integrating a comprehensive review of ergonomic issues to the potential audience. The use of tables throughout the literature could enhance the paper greatly, and improve the readability of disability issues. Many of the readers may thus feel interest on ergonomics of AT. Therefore integration of AT and ergonomics is of vital importance, while data is provided. There are opportunities to be involved with disabilities issues and ergonomics through empirical study results and such information. The needed research agenda should be the theme of the qualitative discussion rather than just discussing the general area of AT and ergonomics. The refereed discussion cited should be further clarified more so that sound arguments are added using concrete materials. The general heuristics on the need of ergonomics is yet to be clear to all audiences that is obvious admirable and undoubtedly a challenge to the authors. There should be take-away message to the readers emphasising more about the latest technology use and user interface issues, for instance. The contexts nicely focused the importance of ergonomics in the design of AT. Indeed, some statements might be informative to a general, although disability research has been able to narrow down certain features of AT. Some arguments in this paper might lay audience.

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