Development of Growth Management Support Tool and Structure of Information Gathering for Child Health

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Abstract:

The school-age period is significant in children's growth process. Children lacking self-management ability require regular support from their surroundings. In particular, educational institutions play an important part, and a health management system based on periodic medical examination is required. In this study, to develop a health management system, a health management process was visualized. In the next step, we developed a problem-finding method. Based on transition in height and weight, we developed a logic for early detection of children with a tendency toward short stature, overweight, and underweight. Additionally, we designed a support tool integrating this logic. The validity and feasibility were confirmed by a specialist by applying this method to actual body measurement data. Finally, we developed a structure of knowledge for cause analysis. For further study, feedback to children and their parents is required to enhance their self-care ability. In addition, it is possible to develop this into a regional health care system for individuals other than children by applying the methodology of regional cooperation.

Keywords

child growth, problem detection, cause analysis, health management, regional cooperation

1. Introduction

1.1 Background

The school-age period is significant in children's growth process. Because children have little self-care skill, individuals in their surroundings, such as parents, need to observe them daily. In particular, elementary schools hold an important role. They conduct periodic health examinations for children, including body measurement, health checkups, testing, and so on. Cotterill et al. (1993) show that body measurement made by them would be sufficiently reliable for screening of growth disorder. School teachers have to manage children's health using these results and promote improvement as needed. There are some merits in utilizing health examination. First, this examination is conducted for all children at stated periods. Second, there are necessary data for screening. Third, teachers can observe and compare children as a group at the same age. Fourth, school nurses are responsible for children's health.

Figure 1. PDCA cycle for children

These health examination data are not used for professional diagnosis but for detection of growth problems in early stages. In addition to early detection, early treatment is also important (Darendeliler et al., 2011; Antoniazzi et al., 2015). If a child has an indication of a problem, the school needs to judge the necessity of medical treatment or not and connect the child to improvement for healthy growth. This Plan, Do, Check, Act (PDCA) cycle for children is depicted in Figure 1.

Growth problems has many different causes (Rogol et al., 2014), and therefore, it is not only a symptom of another disease, but also an environmental condition (Mukaida et al., 2010; Lee et al., 2012; Castano et al., 2013; Naruse et al., 2013; Wattchow et al., 2015). Furthermore, growth problems may cause another problem. For example, younger and shorter children tend to be bullied in the classroom (Naiki et al., 2013). Hence, a focus on the height and weight of the children may facilitate the detection and prevention of various health and social problems.

On the other hand, recently, innovation has been promoted by taking advantage of information and communication technology (ICT) including medical Big Data for quality improvement of medical care and application to clinical study. Aside from the data in medical institutions, we should store data in educational institutions. This stored data will enable health management for children based on their health examination data.

Now, about 80 percent of the public schools in Japan have introduced a “school job support system” to manage a great deal of information, such as individual health information. This is the system in which teachers can share information and process information efficiently. Of course, body measurement data can be stored in this system. Schools have to use this data for screening and to judge whether any intervention is necessary or not.

However, in actuality, although the educational committee, which is responsible for management throughout a region, has the same system, they cannot check data. Further, this system is not utilized effectively in each school. Specifically, the input rate of body measurement data is about 60 percent. One reason is that there is no computer on which to input data in the school infirmary. Another reason is that making school nurses input body measurement data has no merit, because no method has been developed even if they input the data. These facts make it difficult to say that children’s health is managed completely.

1.2. Previous Studies

The method for screening growth disorders of endocrine origin was developed by Okamoto (1989). Using the WHAMES method, school nurses detect serious disorders of endocrine origin in many school-age children. It is the first screening tool for endocrine disorders based on symptom markers such as weight, height, appearance, mentality, emotion, and sexual development (Table 1). After the first screening performed by school nurses, potential patients are sent to Okamoto for diagnosis.

Table 1. The WHAMES method

W ; Weight (screening for obesity and emaciation)		
	obesity	emaciation
Grade	W↑ : extremely overweight w↑ : slightly overweight	W↓ : extremely emaciated w↑ : slightly emaciated
	a : weight gain in a short period of time b : abnormal proportion	a : weight loss in a short period of time b : abnormal proportion
W↑, w↑ and W↓, w↓ and a, b ; each symbol indicates grading of such abnormalities and characteristics.		
H ; Height (screening for short stature or high stature)		
	short stature	high stature
Grade	H↑ : extremely short h↑ : slightly short	H↓ : extremely tall h↑ : slightly tall
	a : impaired growth in body length during a short period b : abnormal proportion	a : over growth in body length during a short period b : abnormal proportion
H↑, h↑ and H↓, h↓ and a, b ; each symbol indicates grading of such abnormalities and characteristics.		
A ; Appearance (screening for abnormal or unusual appearance)		
	abnormal or unusual appearance	
Grade	A : extremely abnormal or unusual appearance a : slightly abnormal or unusual appearance	
	A, a ; each symbol indicates grading of such abnormality.	
M ; Mentality (screening for evaluating mental abilities)		
	impairment in mental abilities	
Grade	M : extremely impaired in mental abilities a : slightly impaired in mental abilities	
	M, m ; each symbol indicates grading of such abnormality.	
E ; Emotion (screening for emotional and behavioral abnormality)		
	emotional and behavioral abnormality	
Grade	E : extremely abnormal in emotion and behavior a : slightly abnormal in emotion and behavior	
	E, e ; each symbol indicates grading of such abnormality.	
S ; Sexual development (screening for abnormal sexual development)		
	precocious puberty	delayed puberty
Grade	S↑ : extremely early sexual development s↑ : slightly early sexual development	S↓ : extremely late sexual development s↑ : slightly late sexual development
	Characteristic a : isosexual precocity b : heterosexual pubertal development	
S↑, s↑ and S↓, s↓ ; each symbol indicates abnormality patterns in sexual development. a, b reveal such characteristics.		

The idea is that school nurses first perform screening in schools. However, this method is troublesome for the nurses as the standard for screening is not clear. In addition, growth disorders of endocrine origin are not the only problems; growth disorders due to environmental factors also need to be considered.

In order to resolve these issues, the WHAMES method needs to be revised to develop a practical method.

We developed an early detection method and support tool for growth disorders utilizing only height data out of all body measurement data (Kariyazaki et al., 2016). Additionally, we developed the outline of a methodology for cause specification.

As the next step, we have to evolve it to cover all growth problems not only growth disorder but also underweight and overweight that can be detected from body measurement data. These are sign of future physical, intellectual, mental disabilities. We also need to develop a knowledge database for cause analysis for practical use.

1.3. Purpose

Schoolchildren have poor self-care ability. Therefore, elementary schools, which perform periodic health examinations, have to manage children's health together with their families. In addition to these, partnership within the regional community, such as the educational committee, local medical association, specialists, and welfare facilities, is required. Hence, a regional health and medical care system for child growth was needed. In order to manage children's health, these support regional player must go through problem detection, cause

analysis, improvement activity, and daily observation processes. Because the processes of problem detection and cause analysis require human judgement, we have to help this processes. Therefore, the purpose of this study is development of growth management support tool for problem detection and structure of information gathering for cause analysis.

2. Direction of the Study

There are processes of problem detection, cause analysis, improvement activity, and daily observation for healthy child growth management. We took advantage of body measurement data from school health examinations to detect “growth problems” efficiently. The methodology for judging the presence or absence of abnormality was developed using indexes of height and weight.

“Growth problem” refers to not only defects that have already occurred but also every matter in need of some action considering both present and future. Therefore, “action” requires regional support such as improvement of lifestyle or living environment.

Next, a “cause” has to be specified in order to solve any problems. This includes not only direct but also indirect factors. We should clarify the relationship between a “growth problem” and its “cause” and decide what kind of intervention is needed. Therefore, we developed this methodology.

This system consists of core, support, and management systems (Figure 2).

- core system: processes associated directly with health management service from problem detection to daily observation

- support system: necessities for the core system such as human resources, tools, information technology and so on

- management system: a section for overall grasp and management

In accordance with this system design, this study developed support method for problem detection and cause analysis processes.

Figure 2. System design

We obtained agreement for this study from the board of education and medical association of District K, the Jikei University School of Medicine, and the University of Tokyo. District K has about 50 public elementary schools, and the living standard of this district is considered approximately the same as the national standard.

The ethics committee of the Jikei University School of Medicine approved the study, and children's health data were anonymized.

3. Study Methods

3.1 Visualization of Process Flowchart

The management process for children's healthy growth should be clarified. Therefore, we visualized the works of regional people involved in this process, including school nurses, who have responsibility for health management of children at school. This visualization required surveys of pediatricians and school nurses.

3.2 Development of Problem Detecting Logic

The input for problem detecting is body measurement data. Growth disorder, overweight, and underweight are considered physical findings indicating growth problems. We developed decision logic for these levels for each physical finding. Output is derivation of the next unit.

3.3 Development of a Support Tool

It is difficult for school nurses to understand and manage all the health conditions of children because of a lack of knowledge, intuition, and time. In particular, it is their responsibility to plot the growth curves of children and detect growth problems, which can be burdensome. Therefore, we developed a support tool necessary for realization of the judgement based on the logic in 3.2.

3.4 Design of Database Structure for Cause Analysis

There are many factors in problem occurrence. Accordingly, it is necessary to grasp the structure and mechanism of problems in order to specify a real cause from many assumed causes. This cause specification requires certain information, but children's self-care ability is so poor that they cannot evaluate objectively. Therefore, it is important to gather information from within and outside of schools. We considered characteristics of educational institutions and regional cooperation and drew an outline of cause analysis. Based on this outline, we designed a database structure for cause analysis.

4. Study Results

4.1 Visualization of Process Flowchart

We visualized the work process for health management of children in a flowchart (Figure 3). The vertical axis represents job phase: the phase of problem detecting, cause analysis, improvement activity, and observation. The persons in charge expand along the horizontal axis. In this case, the following persons are incorporated, based on a previous study (Tsuru et al., 2014).

- People at home: They are the most familiar with the child.
- Homeroom teachers: They are familiar with the children and have an objective viewpoint.
- School nurses and school physicians: They have specialized knowledge about the health care of school children.
- Specialists: They have specialized knowledge about medical care.
- Principals and board of education: They have responsibility for the whole school or the whole area.

Figure 3. The work process flowchart for health management of children

4.2 Development of Problem Detecting Logic

We developed decision logic levels for three physical findings—growth disorder, overweight, and underweight—from height and weight data. This logic is methodology to judge the following four stages based on definition and present standard.

- Level 1: There is no doubt about a growth problem.
- Level 2: There is doubt about it based on coexistence of other findings.
- Level 3 : There is doubt about it.
- Level 4: There is a growth problem.

4.2.1 Judgement from Height Data

Growth disorder as a disease requiring medical treatment in a hospital has two types. One is short stature and the other is growth failure. Short stature is defined as a standing height more than 2.0 standard deviations (SDs) below the mean for age and sex. The data in the School Health Statistical Research Report (2000) are used for calculation of SD score. There is little difference in the physical builds between children in 2000 and children today, so these data are generally used. In contrast, growth failure is difficult to define (Stalman et al., 2015), and hence, various studies have defined it differently. For example, Jonathan (2004) defined it as growth deceleration (falling across major percentiles on the growth curve).

To detect growth disorders, height velocity has to be calculated and plotted accurately on a growth chart, considering the birth month of each child (Murata, 2014). It is difficult even for specialists to diagnose growth disorders based on growth charts. However, in elementary schools, school nurses need to plot growth charts and detect growth disorders in a limited time. Therefore, we provided a diagnosis support method to enable non-specialists to diagnose suspected growth disorders in as similar a manner as a specialist as possible without their ability hindering the process.

Garner et al. (2000) developed a systematic review of trials in order to improve nutrition, reduce the risk of death or inadequate nutrition, help educate carers, and lead to early referral for conditions manifest by growth disorders. However, it was only an empirical model and there were few strong evidence.

This methodology aims to detect not only disease that has already occurred but also the matter of any necessary improvement in the future. Therefore, we calculated a height prediction line from present height velocity SD score. When this line is lower than the 2.0 SD line, the child requires screening.

Moreover, in order to detect other factors of stagnant growth besides disease, we created the condition to judge presence or absence of abnormality from height velocity SD score by application of a quality control chart. The problem detection logic developed after discussion with a specialist is depicted in Figure 4.

Figure 4. Judgement from height data

4.2.2 Judgement from Weight Data

Rankin (2016) suggested the possibility that overweight and underweight in childhood leads to not only future diseases but also psychiatric disturbances. Physical builds cannot be evaluated by SD score because the weight data do not follow normal distribution. The obesity index is calculated for evaluation of overweight and underweight. It is calculated by the following equation.

$$\text{obesity index} = \frac{\text{measuring weight} - \text{standard weight}}{\text{standard weight}} \times 100 [\%] \quad (1)$$

The standard weight is calculated for age and sex. The definition of risk level based on obesity is depicted in Table 2. This definition refers to decision criteria of “health examination for prevention of children lifestyle-related disease.” The decision method from weight data is depicted in Table 2.

Table 2. Judgement from weight data

General Judgement	Extremely Underweight	Underweight	Normal	Slightly Overweight	Overweight	Extremely Overweight
Obesity Index	~ - 30%	- 30%~ - 20%	- 20%~ 20%	20%~ 30%	30%~ 50%	50%~
Underweight Level	3	2	1	—	—	—
Overweight Level	—	—	1	2	3	4

4.2.3 Comprehensive Judgement

The state of children’s growth is classified into “normally,” “observation,” and “cause analysis” through a combination of physical findings based on height and weight (Figure 5). The children classified into “normally” and “observation” transfer to the phase of observation. However, the management levels of the two are different. The observers should watch the latter carefully. On the other hand, the other children shift to the “cause analysis” phase.

Figure 5. Comprehensive Judgement

4.3 Development of a Support Tool

We developed a support tool that can utilize the body measurement data efficiently and effectively and extract information necessary to analyze the growth problem. This support is mainly for early detection, since the tool can calculate the SD score and obesity index and plot the growth curves of all children based on the data input into the school job support system. It can thereby diagnose growth problems automatically, using the previously mentioned rule. Height and weight data and the growth chart for each child are output in a single sheet. When a child is suspected to have a growth disorder, the tool outputs a danger signal. Aside from the personal data sheet, this tool has functions to visualize the distribution of all school data and to search optional children in a collective data sheet. The personal data sheet is depicted in Figure 6.

Figure 6. The personal data sheet in growth management support tool

4.4 Design of Database Structure for Cause Analysis

The factors of growth disorder, overweight and underweight, are roughly divided into four types: genetic factor, disease, lifestyle factor, and mental factor. The relation between these factors and growth problems appearing as physical findings vary, as in Table 3.

Table 3. The relation between these factors and growth problems appearing as physical findings

	The Schematic Figure	Concrete Example
1		F : Short Stature
2		D : Small for Gestational Age Infant F : Short Stature
3		D : Prader-Willi Syndrome F : Short Stature, Obesity
4		L : Disorder of the Lifestyle F : Obesity
5		M : Excessive Stress F : Underweight
6		D : Delayed Puberty F : Growth Failure
7		L : Disorder of Nutrient Balance D : Diabetes Mellitus F : Obesity
8		D : Allergic Disease L : Nutritional Deficiency F : Short Stature, Underweight

Therefore, cause analysis of the problem is important in order to specify the real cause from many assumed causes. Information is gathered by referring to past body measurement data and medical check-up sheets and asking questions of people at home and homeroom teachers. This outline is depicted in Figure 7.

Figure7. The outline of cause analysis

We designed the database structure for cause analysis based on this outline. Under the leadership of two pediatricians, we extracted the causes by a literature search (Tanaka et al., 1997; Tanaka, 2002; Kinoshita, 2012; Cook and Rose, 2012) for growth disorder, underweight and overweight, respectively. This database structure includes the following three correspondence tables (Figure 8):

- ① physical findings—all estimated factors
- ② all estimated factors—information to narrow down the factors
- ③ information to narrow down the factors—target to acquire the information

disorders due to environmental factors are not considered. However, some difficulties remain to be addressed using the cause analysis method. The person who conducts cause analysis needs to be able to refer to past body measurement data and medical check-up sheets. Because of this, this should be a person in the school. To be honest, it is appreciated that school nurses can conduct cause analysis, but the support of school principals and homeroom teachers is required considering school scale and the position of school nurses in school.

7. Conclusion

The pilot study confirmed the feasibility and usefulness of the method and tool for problem detecting. Moreover, we were able to cover all health problems using weight data in addition to height data. Further, it is safe to say that our method can solve the problems of the WHAMES method that the standard for screening is not clear and growth problems due to environmental factors are not considered. These must be helpful for efficient health management of early detection of children's growth problems. In this way, when the importance and merit of storing body measurement data as electric data are to be understood, input of data into the school job support system will be enhanced. This leads to acceleration of medical industry ICT and the educational industry.

In the future, we must develop a concrete method for cause analysis incorporating executor. Development will lead to the effective improvement of children's growth. Moreover, if children and their families can receive the personal data sheets after every body measurement, their self-care ability must be enhanced. Finally, application of the regional cooperation methodology will realize a regional health and medical care system for all inhabitants from infancy to adulthood.

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