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Original Article

Recognition of, interest in, and understanding of induced pluripotent stem cells and regenerative medicine in Japanese students

Kenji Ishihara [a, *], Asuka Ichinomiya [a, 1], Mami Inami [a, 1], Tomomi Hashimoto [a, 1], Rie Yuzawa [a, 1], Miari Ishizu [a, 1], Toshie Hirohara [a], Yoshimi Yashiro [b], Toshiyuki Takizawa [a]

[a] Course for School Nurse Teacher, Faculty of Education, Ibaraki University, Japan
[b] Uehiro Research Division for iPS Cell Ethics, Center for iPS Cell Research and Application (CiRA), Kyoto University, Japan

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ABSTRACT

We studied the recognition of, interest in, and understanding of induced pluripotent stem (iPS) cells and regenerative medicine in a total of 2659 junior high school, senior high school, and university students. The number of valid responses received was 2396 (90.1%). We report the following seven observations [1]. More than 80% of students reported recognition of iPS cells, regenerative medicine, and Professor Shinya Yamanaka, and a similar number were interested in and supportive of regenerative medicine [2]. Regenerative medicine was viewed as a medical treatment option. However, females were more cautious regarding use of regenerative medicine as a treatment compared with males [3]. Approximately 90% of students were interested in the latest medical care. Among the new treatment methods, they more frequently selected those that they were more familiar with and perceived less invasive to be ideal [4]. Regarding organ or tissue donation in regenerative medicine, students focused more on the characteristics of the donors [5]. Approximately 90% were supportive of storing their own cells. However, approximately 50% of students supported storing iPS cells for use in regenerative medicine [6]. Most students were anxious regarding the side effects, safety, and treatment costs of regenerative medicine, but supported the need of education regarding regenerative medicine [7]. More than 70% of students thought that education of regenerative medicine was necessary for the public. These findings suggest the importance of social approach, in addition to medical approach such as research and development, to improve QOL in community by developing the public understanding of regenerative medicine through science communication and school education, for the establishment of systems to promote this field.

1. Introduction

Induced pluripotent stem (iPS) cells were first reported after the reprogramming of mouse fibroblasts in 2006, and human fibroblasts in 2007 [1–3]. The cells were originally generated by introduction of the *OCT3/4*, *SOX2*, *KLF4*, and *c-MYC* genes by a retrovirus [1]. More effective experimental procedures have since been developed to obtain iPS cells from somatic cells by expression of various combinations of transcription factors or by addition of chemical compounds [3–12]. Professor Shinya Yamanaka, director of the Center for iPS Cell Research and Application (CiRA) in Kyoto University, won the Nobel Prize in Physiology or Medicine in 2012, by his series of such studies.

Stem cells, which include somatic stem cells such as hematopoietic cells, embryonic stem (ES) cells, and iPS cells, have both self-renewal capability and ability to give rise to differentiated cell lines [13,14]. Tissue homeostasis is maintained via the self-renewal and differentiation of somatic stem cells. Especially, hematopoietic stem cells can enter the cell cycle and either self-renew or differentiate into multipotent progenitors that provide diverse mature blood cells [15]. On the other hand, ES cells that obtain from inner cell mass of mammalian embryos in blastocyst stage, have been reported to be established in mouse in 1981 [16,17] and human in 1998 [18]. The capacity for unlimited growth and potential to

* Corresponding author. Laboratory of Medical Science, Course for School Nurse Teacher, Faculty of Education, Ibaraki University, 2-1-1 Bunkyo, Mito, Ibaraki 310-8512, Japan. Fax: +81 29 228 8300.
E-mail address: kenji.ishihara.phd@vc.ibaraki.ac.jp (K. Ishihara).
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[1] Equal contribution.

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develop into all cell types in the adult organism of ES cells has suggested the possibility for cell transplantation therapy, drug screening or toxicity by using patient-specific differentiated cells. However, as for organ transplants, tissue rejection remains a significant concern for ES cell transplantation. Another concern is the use of human embryos [19]. Therefore, establishment of iPS cells in human in 2007 promoted regenerative medicine due to the resolve of the ethical problems of ES cells. The great efforts of the researchers have found possibility of the transplantation therapy with stem cells. QOL of patients is about to improvement by these medical approach.

iPS cells theoretically possess the ability to differentiate into any type of cell allowing construction of various tissues and organs, and have the advantage of being able to be prepared using somatic cells collected directly from the patient. iPS cells provide the opportunity for widespread application, not only limited to cell transplantation therapy, but also for disease modeling *in vitro* for investigation of pathogenesis and drug screening for novel medications [19–21]. Therefore, multilateral studies, including preparation of tissues and organs, construction of iPS cell stocks for transplantation, as well as basic studies of the reprogramming mechanism for iPS cells from somatic cells, were started all over the world. In Japan, the Ministry of Education, Culture, Sports, Science and Technology-Japan (MEXT) has started various projects for the realization of regenerative medicine using iPS cells from 2007 [22,23]. In 2014, clinical research on age-related macular degeneration using patient iPS cell-derived retinal pigment epithelial cells was started by Dr. Masayo Takahashi's team [24,25]. Although fibroblasts were originally used the somatic cells for the preparation of iPS cells [1–3], modified methods utilizing while blood cells [11] and a feeder-free culture system [12] have been established for use in medical treatment. The construction of medical iPS cells stocks was discussed among the Ministry of Health, Labour and Welfare (MHLW) [26], CiRA, and the Japanese Red Cross Society, and these organizations have begun to cooperate in its construction. For transplantation of an organ or tissue, it is necessary to at least partially match the human leukocyte antigen (HLA) between the donor and recipient to reduce the incidence of graft rejection; three loci, HLA-A, -B, and DR, are important for this process [27,28]. Okita et al. estimated that the establishment of 140 HLA-homozygous lines for iPS cells selected from 160,000 individuals would provide a match for 90% of the Japanese population [10]. Therefore, the understanding and cooperation of the Japanese public for the construction of such an iPS cell stock is essential.

Recently, importance of science communication is pointed out. After nuclear power disaster in Fukushima, communication gap among scientists, media, and the public was indicated [29,30], and then Horiguchi suggested that training for the skill improvement is essential in the risk communication among them [30]. Concerning iPS cells and regenerative medicine, on the other hand, the area of interest about iPS cells differs among scientists, media, and the public [31], and Hatta has mentioned there is a gap in ability of the regenerative medicine and social expectation [32]. It seems to be insufficient that our public has an individual opinion through science communication and education, although 10 years are going to pass since the establishment of iPS cells. The knowledge about the regenerative medicine of the public was based on information obtained from the media particularly TV [33,34]. Although, the public thought to be familiar with the terms iPS cells and regenerative medicine, they decided to adopt a “wait and see” approach [34]. In this survey [34], the number of responders younger than 20 years old who are essentially the stakeholders of such a technology when regenerative medicine is realized, was remarkably low, because it was targeted to members of a particular company as well as newspaper readers. Therefore, it is remained to be elucidated how the Japanese students feel about iPS cells and regenerative medicine. By medical approach, which is effort of researchers in research and development such as establishment of ES cells and iPS cells, and laboratory to clinical research, regenerative medicine might realize as one of the medical cares in future. Therefore, social approach, which is the public understanding of regenerative medicine through science communication and school education to construct better medical care with medical approach, plays critical roles for the realization. Thus, they are important for us to understand science knowledge and technical terms for regenerative medicine through them, and then to construct better medical care with medical approach, or to be able to understand the medical care when we receive it. Such social approach to improve consciousness of the public might be necessary for realization of regenerative medicine together with medical approach.

Therefore, in the present study, we investigated the recognition of, interest in, and understanding of iPS cells and regenerative medicine in junior high school, senior high school, and university students.

2. Methods

2.1. Participants

Participants were 2659 students at five junior high schools, two high schools, and five universities. The number of valid responses received was 2396 (male: n = 967, female: n = 1429) (junior high school: n = 724, high school n = 866, university n = 806) with a valid responses rate of 90.1%. This study applies judgmental sampling design. We asked principal and faculty to perform questionnaire by mail. The school and faculty which obtained its consent were qualified in the sex ratio of pupils, a scale of the class, and achievement level of pupils. Students in schools that obtained consent from principal and faculty, filled out a questionnaire. Numbers of participants in each school depended on the circumstance. Because numbers of participants among kind of schools adjusted almost same, numbers of schools in kind of schools has been different. The survey was conducted between October and November 2013 under the supervision of classroom teachers in each school.

2.2. Questionnaire

The questionnaire contained 19 questions covering the following 5 categories: (1) background of responder, (2) recognition of iPS cells and regenerative medicine, (3) future medical development, (4) relationship between the public and regenerative medicine, and (5) education for regenerative medicine (Table 1).

2.3. Statistical analysis

SPSS statistics version 20 (IBM Japan, Tokyo) was used for statistical analysis. Pearson's chi-square test was used to compare differences with respect to sex and kind of school.

2.4. Ethical consideration

We explained the purpose of this research to the principal and faculty of each junior high school, high school, and university. Teachers supervising the questionnaire verbally explained to the students that participation was anonymous and voluntary, and that the data would be used only for the purpose of this research.