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Original article

Implications of the diagnosis of locomotive syndrome stage 3 for long-term care

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ABSTRACT

Objectives: Locomotive syndrome stage 3 (LS3), which has been established recently, may imply a greater need for care than LS stage 0 (LS0), LS stage 1 (LS1), and LS stage 2 (LS2). The relationship between LS3 and long-term care in Japan is unclear. Therefore, this study aimed to examine this relationship.

Methods: A total of 531 patients (314 women and 217 men; mean age, 75 years) who were not classified as requiring long-term care and underwent musculoskeletal examinations in 2012 were grouped according to their LS stage. Group L comprised patients with LS3 and Group N comprised those with LS0, LS1, and LS2. We compared these groups according to their epidemiology results and long-term care requirements from 2013 to 2018.

Results: Fifty-nine patients (11.1%) were diagnosed with LS3. Group L comprised more patients (50.8%) who required long-term care than Group N (17.8%) ($P < 0.001$). Group L also comprised more patients with vertebral fractures and knee osteoarthritis than Group N (33.9% vs 19.5% [$P = 0.011$] and 78% vs 56.4% [$P < 0.001$], respectively). A Cox proportional hazards model and Kaplan–Meier analysis revealed a significant difference in the need for nursing care between Groups L and N (log-rank test, $P < 0.001$; hazard ratio, 2.236; 95% confidence interval, 1.451–3.447).

Conclusions: Between 2012 and 2018, 50% of patients with LS3 required nursing care. Therefore, LS3 is a high-risk condition that necessitates interventions. Approaches to vertebral fractures and osteoarthritis of the knee could be key.

1. Introduction

The worldwide population is aging; therefore, studies of sarcopenia and frailty have been performed to help extend healthy life expectancies [1,2]. These studies have assessed not only physical functions but also oral health, nutrition, internal medicine, psychology, and social resources, such as social security and social systems. The aging population in Japan is increasing significantly; therefore, a long-term care insurance system has been implemented to provide comprehensive care, including nursing care, to older individuals [3–5]. Because musculoskeletal disorders are the main reasons for requiring long-term care, the Japanese Orthopaedic Association has established the concept of locomotive syndrome (LS) and is attempting to prevent it [6]. Factors of LS include osteoporosis, fractures, and osteoarthritis, and there is still a lack of research on how these are related to LS [7].

In 2020, LS stage 3 (LS3), which comprises a state of advanced mobility impairment, was defined [7]. LS3 comprises physical frailty and is expected to be the reference for medical countermeasures created for LS. It is considered that LS3 requires more care than LS stage 0 (LS0), LS stage 1 (LS1), and LS stage 2 (LS2), but there is hardly any research on

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its significance or its relationship with the need for care. There are two papers that have examined the presence or absence of the need for care in LS3 [8,9], but they have not examined the degree of care needed, nor have they investigated vertebral fractures or osteoarthritis. Therefore, there is a lack of research on the usefulness of this diagnosis for predicting the risk of LS3, the degree of care needed, or the level of care required.

In 2012, our department conducted a study of the relationships between LS (LS1 and LS2), nursing care, and musculoskeletal diseases [10,11]; however, at that time, criteria for LS3 had not yet been established. Therefore, this study aimed to examine the relationship between LS3 and its nursing care and to investigate how factors such as vertebral fractures and osteoarthritis affect LS3.

2. Methods

The study protocol was approved by the Institutional Review Board of our university (IRB No.22-135), and the study procedures were performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants. This study retroactively applied the classification criteria created in 2020 to datasets from 2012.

2.1. Participants

The participants were community-dwelling volunteers who underwent a health examination provided by the local government in 2012 and consented to participate in a previous study [10,11]. The inclusion criteria were age 65 years or older and the ability to answer the questionnaires independently. The exclusion criteria were inability to walk without the assistance of others, received nursing care in 2012, and provided incomplete responses to the questionnaires. Demographic data, radiographic data, and responses to the 25-question Geriatric Locomotive Function Scale (GLFS-25) [12] of all participants were obtained. The GLFS-25 is a comprehensive self-administered questionnaire comprising 25 items. Care needs were surveyed annually from 2012 to 2018.

2.2. Locomotive syndrome evaluation

The LS stage was determined using the GLFS-25. Each item was rated using a 4-point scale, with a minimum total score of 0 and a maximum total score of 100. According to the clinical decision limits of the GLFS-25 [7], scores of 0–6, 7 to 15, 16 to 23, and 24 or more indicated stages 0, 1, 2, and 3, respectively. To investigate the risk of LS3, participants with LS0, LS1, and LS2 were classified as Group N, and those with LS3 were classified as Group L. We compared LS3 to LS0, LS1, and LS2 as defined by the 2012 criteria. Based on the initially diagnosed disease stages of these patients, we also compared long-term care required during 2012–2018.

2.3. Evaluation of the required level of care

The nursing care level was based on evaluations by the Japanese Long-term Insurance System [4]. Based on the information collected from the claimant (patient) and physician, the needs of the claimant were assessed and the required care was divided into seven levels, including two support levels (levels 1 and 2; requiring support to perform independent activities of daily living) and five care levels (levels 1–5; requiring daily nursing care). Higher levels were associated with greater disease severity. A baseline survey was conducted in 2012. From 2013 to 2018, we surveyed whether nursing care was required and whether care needs changed every year. Whether nursing care was required was surveyed each year from 2012 to 2018.

2.4. Investigation and radiographic evaluation of musculoskeletal diseases

Musculoskeletal diseases were evaluated using radiography images obtained in 2012. Vertebral fractures and hip and knee joint osteoarthritis were also investigated. Anterolateral whole-spine and whole-leg radiography images were obtained and evaluated by two orthopedic surgeons [13]. Vertebral fractures were diagnosed as grade 2 or higher using a semi-quantitative technique [14], hip osteoarthritis was diagnosed as advanced stage or higher using the Japanese Orthopaedic Association classification [15], and knee osteoarthritis was diagnosed as 2 or higher according to the Kellgren–Lawrence classification [16].

2.5. Statistical analysis

SPSS version 25 (IBM SPSS Corp., Armonk, NY, USA) was used to perform all statistical analyses. Descriptive statistics, including means and standard deviations (SDs), of the demographic data were calculated. The participants were divided into the following age groups: 65–74 years, 75–84 years, and 85 years or older. In the evaluation among the three groups by age, if there is a significant difference ($P < 0.05$) using the Chi-square test, a post-hoc analysis with Bonferroni test was performed. Differences in demographics, imaging results, and nursing care requirements were compared between Groups N and L using unpaired *t*-tests and chi-square tests. Unpaired *t*-tests were used to compare quantitative variables among groups, and chi-square tests were used to compare categorical variables. Survival curves were created using the Kaplan–Meier method, with nursing care requirements as the endpoint. The Cox proportional hazards model was used to analyze the hazard ratio (HR) for requiring nursing care in the future. $P < 0.05$ was considered statistically significant.

3. Results

A total of 728 participants were initially enrolled in this study; of these, 197 participants were excluded based on the criteria. A total of 531 participants (314 [59.1%] female and 217 [40.9%] male participants; mean age, 75.3 years [SD, ± 5.8 years]; range 65–92 years; 2012 data) were enrolled (Fig. 1).

Based on 2012 data, 243 (45.8%) participants had LS0, 161 (30.3%) had LS1, 68 (12.8%) had LS2, and 59 (11.1%) had LS3 (Fig. 2). The prevalence rates of LS3 increased with age ($P = 0.001$); 5.9%, 15.3%, and 19.4% of patients with LS3 were in the 65–74 years, 75–84 years, and 85 years or older age groups, respectively. LS2 and LS3 cases were similarly distributed in the 75–84 years age group, and more cases of LS3 were observed in the 85 years or older age group than in the other age groups.

Between 2013 and 2018, 114 (21.4%) individuals required long-term care (mean observation period, 1978 days; SD, ± 496 days). The required care levels of these 114 individuals were as follows: 17 required support level 1, 19 required support level 2, 21 required care level 1, 20 required care level 2, 14 required care level 3, 15 required care level 4, and 8 required care level 5 (Fig. 3). There was no trend in the number of elapsed years and an increase in the number of individuals who required care. However, the number of participants who required care increased as age increased, with 7.9% ($N = 20$) of those 74 years or younger being classified as requiring long-term care and 58.2% ($N = 21$) of those 85 years or older classified as requiring long-term care (In the chi-square test, the P-value was < 0.001, and with Bonferroni post-hoc analysis, all three-group comparisons had P-values < 0.05.).

According to an evaluation of 2012 radiography data of Group L, 112 (21.1%) participants had vertebral fractures, 47 (8.9%) had hip osteoarthritis, and 312 (58.8%) had knee osteoarthritis. Furthermore, the prevalence rates of vertebral fractures ($P < 0.001$) and knee osteoarthritis ($P < 0.001$) increased with age; however, age did not affect hip osteoarthritis ($P = 0.370$) (Fig. 4).

A comparison of these data of Groups N and L are presented in

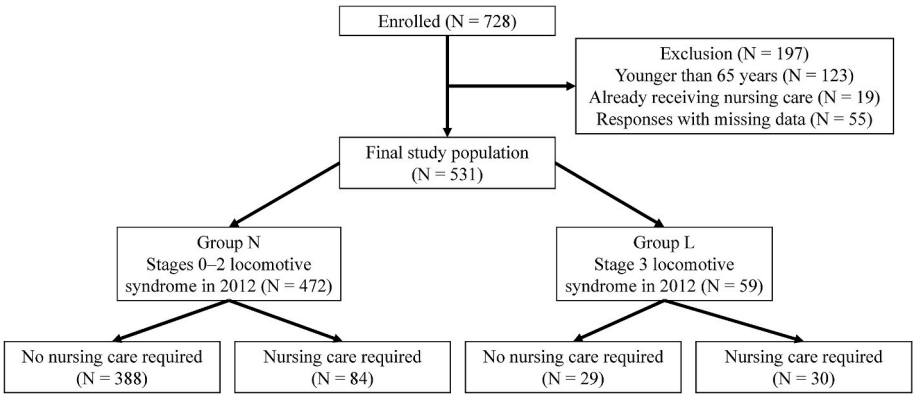

Fig. 1. Flow diagram of the study participants.

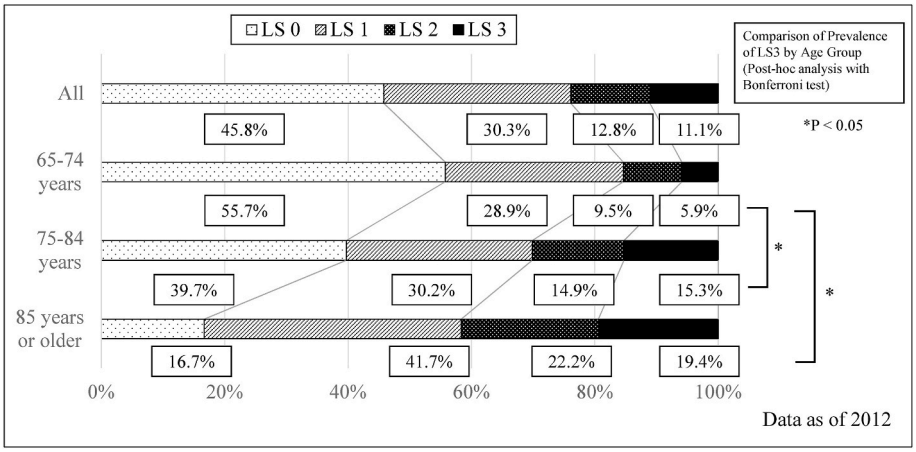

Fig. 2. Prevalence rates of locomotive syndrome and changes according to age groups.

Fig. 3. Nursing care and support requirements according to years elapsed since 2012.

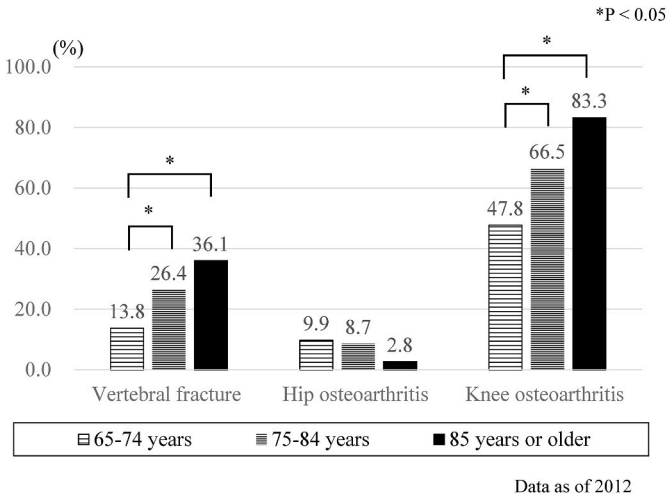

Fig. 4. Prevalence rates of vertebral fractures and osteoarthritis.

Table 1
Comparison of the Group N and Group L.

	Group N (N = 472)	Group L (N = 59)	P-value
Data from 2012			
Female patients, N (%)	275 (58.3%)	39 (66.1%)	0.249
Age, yrs	74.9 ± 5.8	78.7 ± 5.4	< 0.001
Height, cm	153.6 ± 8.8	149.9 ± 8.9	0.001
Body weight, kg	53.0 ± 9.1	51.8 ± 8.2	0.443
BMI, kg/m^2	22.4 ± 2.8	23.3 ± 2.4	0.009
Vertebral fracture, N (%)	92 (19.5%)	20 (33.9%)	0.011
Hip osteoarthritis, N (%)	38 (8.1%)	9 (15.2%)	0.067
Knee osteoarthritis, N (%)	266 (56.4%)	46 (78.0%)	0.001
Data from 2013 to 2018			
Required nursing, N (%)	84 (17.8%)	30 (50.8%)	< 0.001
65–74 yrs	17 (7.1%)	3 (20%)	
75–84 yrs	52 (25.4%)	21 (56.8%)	
85 yrs or older	15 (51.7%)	6 (85.7%)	
The level of nursing care, N (%)			< 0.001
Support level 1	12 (14.3%)	5 (16.7%)	
Support level 2	13 (15.5%)	6 (20%)	
Care level 1	15 (17.9%)	6 (20%)	
Care level 2	16 (19%)	4 (13.3%)	
Care level 3	10 (11.9%)	4 (13.3%)	
Care level 4	12 (14.3%)	3 (10%)	
Care level 5	6 (7.1%)	2 (6.7%)	

BMI, body mass index. Group L (Locomotive Syndrome stage 3). Group N (Locomotive Syndrome stage 0~2).

Table 1. Based on the 2012 data, there were significant differences in age (P < 0.001), height (P = 0.001), and body mass index (P = 0.009) at baseline. The incidence of vertebral fractures was significantly higher (P = 0.011) in Group L (33.9%) than in Group N (19.5%). The incidence of knee osteoarthritis was also significantly higher (P < 0.001) in Group L than in Group N (78% and 56.4%, respectively); however, hip osteoarthritis did not differ significantly between groups (P = 0.067). Based on the 2013 to 2018 data, the proportion of patients receiving care (P < 0.001) and the level of nursing care were significantly higher (P < 0.001) in Group L than in Group N. In Group L, 3 of 15 (20%), 21 of 37 (56.8%), and 6 of 7 (85.72%) patients in the 65–74 years, 75–84 years, and 85 years or older age groups, respectively, were receiving care; these proportions were higher than those of Group N (P < 0.001).

A survival analysis using the log-rank test showed a significant difference between Groups N and L (P < 0.001) in terms of nursing care as an endpoint (Fig. 5). The Cox proportional hazards model was used to

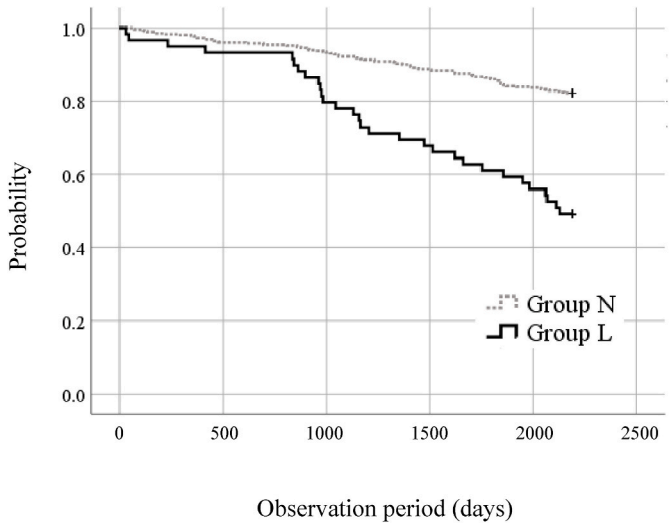

Fig. 5. Survival analysis of long-term care using the Kaplan–Meier method with nursing care needs as the endpoint. Group L (Locomotive Syndrome stage 3). Group N (Locomotive Syndrome stage 0~2).

Table 2
Cox proportional hazards model with the need for nursing care as the objective variable.

Factor	HR	95% CI	P-value
Crude model			
LS3	3.485	2.295–5.291	< 0.001
Explanatory variables			
Age	1.150	1.114–1.187	< 0.001
Sex	0.928	0.639–1.349	0.696
LS3	2.236	1.451–3.447	< 0.001

CI, confidence interval; HR, hazard ratio; LS3, stage 3 locomotive syndrome.

calculate the HR for requiring future nursing care and showed a significant association with LS3 in a crude model (HR, 3.485; 95% confidence interval [CI], 2.295–5.291; P < 0.001) and a model adjusted for age and sex (HR, 2.236; 95% CI, 1.451–3.447; P < 0.001) (Table 2).

4. Discussion

During this study, we evaluated the relationship between LS3 and long-term nursing care. In 2012, the initial prevalence rates of LS1, LS2, and LS3 were 30.3%, 12.8%, and 11.1%, respectively, among this study population. During the 6-year follow-up period, 21.4% of the overall study population required long-term care; of these patients, 50.8% were initially diagnosed with LS3 in 2012, indicating that this population has a greater need for care (P < 0.001). For patients diagnosed with LS3, the risk of requiring long-term care was 2.2 times higher (HR, 2.236; 95% CI, 1.451–3.447; P < 0.001) than that for patients diagnosed with LS0, LS1, or LS2.

Several studies have recounted the prevalence of LS3. Although background factors differed, a nationwide data study (N = 8681; mean age, 51.6 years [SD, ± 18.2 years]; age range, 20–89 years) reported an LS3 prevalence of 3.2% (restricted to the 65–89 years age group: 196 of 2635 [7.4%] patients) [17]. The ROAD study (N = 1575; mean age, 65.6 years [SD, ± 13.0 years]) reported an LS3 prevalence of 11.6% [8]. The Nagahama study (N = 2077; mean age, 68.3 years [SD, ± 5.4 years]) reported LS3 prevalence rates of 6.5% and 15.4% for the overall population and patients 75 years or older, respectively [18]. During the present study, the LS3 prevalence (11.1%) was similar to or slightly higher than those published previously, possibly because the mean age of the patients was 75.3 years (SD, ± 5.8 years), which was older than that reported by previous relevant studies. Additionally, the prevalence

rates according to age were similar to those reported by previous studies. Therefore, the epidemiological data used for this study were considered reliable.

Two previous studies evaluated the risk of requiring nursing care attributable to LS3. Yoshimura et al. [8] reported that a logistic regression analysis indicated that LS3 significantly increased the risks of disability (odds ratio [OR], 3.63; 95% CI, 1.41–9.31; $P < 0.05$) and mortality (OR, 3.78; 95% CI, 1.55–9.25; $P = 0.004$) compared to those of LS0. Kitaura et al. [9] reported that LS3 was an independent risk factor for requiring nursing care for musculoskeletal disorders (HR, 3.89; 95% CI, 1.01–15.0; $P = 0.046$). The present study found that the risk of requiring nursing care was 3.5 times higher (HR, 3.485; 95% CI, 2.295–5.291; $P < 0.001$) for those with LS3 compared to that for patients with LS0, LS1, and LS2; furthermore, 30 of 59 (50.8%) patients with LS3 required nursing care within 6 years. Moreover, the level of nursing care was higher for Group L (with LS3) than for Group N (LS0, LS1, or LS2). According to the study by Kitaura [9], 21 of 35 (60%) patients with LS3 required long-term care within 6 years. Approximately half of the patients diagnosed with LS3 are at risk for deteriorating health requiring a higher level of long-term care in the near future, thus implying that early intervention is mandatory for LS3.

Aging is also a risk factor for LS-associated health deterioration requiring nursing care. During this study, LS2 was more prevalent than LS3 among patients in the 65–74 years age group; however, LS2 was as prevalent as or more prevalent than LS3 among patients in the 75–84 years and 85 years or older age groups. Similarly, Taniguchi et al. [18] found that the prevalence rates of LS3 were higher than those of LS2 among patients 70–74 years of age (LS2, 7.4%; LS3, 8.0%) and those 75 years or older (LS2, 6.9%; LS3, 15.4%). These results indicated that LS may rapidly worsen in some patients 75 years or older.

The mobility of older individuals varies widely, and the time course of mobility deterioration is extremely heterogeneous [19]. Some studies have suggested that mental health and physical health are well-maintained among those 65–74 years of age and that most of these individuals are capable of participating in social activities [20]. Sarcopenia, which accelerates the deterioration of LS, appears to be more prevalent among those 70–79 years of age [21]. According to our survey, 82.4% (94 of 114) of patients who required nursing care were 75 years or older. Based on these epidemiological data and the risk of LS3, we recommend LS screening at approximately 75 years of age and mandatory intervention for LS3.

Because Group L (with LS3) had a significantly higher prevalence of vertebral fractures and knee osteoarthritis during this study, the management of osteoporosis-related and knee diseases may be integral to preventing the need for long-term care and improving LS3. The leading cause of long-term care among those needing support level is joint disorders, while among those requiring care level, fractures and falls are the third most common. The Nagahama study reported that patients with LS3 had higher rates of osteoporosis and knee pain (29.4% and 58.8%, respectively) than those with LS2 (18.3% and 47.8%, respectively) [18]. To the best of our knowledge, most improvements in LS3 have been associated with surgical treatments. Although the timing of outcome assessments has varied, 42.5% of patients with spinal disease, 46.7%–75.6% of patients who have undergone total hip replacement, and 27.7%–55.2% of patients who have undergone total knee replacement exhibited improvements in LS3 [22–25]. LS3 improvement requires medical interventions, such as treatments for osteoporosis and musculoskeletal disorders. Additionally, surgical interventions by an orthopedic surgeon are sometimes required. Therefore, patients with LS3 require not only health examinations but also interventions, including medical and/or surgical treatments.

This study had some limitations. First, the sample size was relatively small. Second, the survey was performed among patients in a relatively rural area. These selection biases should be considered when generalizing the results of this study. Third, only the GLFS-25 was used to diagnose LS. Fourth, the participants were able to walk by themselves and may have had a high level of health consciousness, which may have led to an underestimation of risk. Nonetheless, this study is valuable because it used data from previous longitudinal studies to clarify the relationship among LS3, the need for nursing care, vertebral fractures, and osteoarthritis.

5. Conclusions

LS3 is a dangerous condition that results in approximately half of all patients requiring long-term care. Therefore, interventions are necessary, particularly for those 75 years or older.

CRediT author statement

Koichiro Ide: Investigation, Methodology, Validation, Visualization, and Writing - original draft. **Yu Yamato:** Investigation, Writing - review & editing, and Supervision. **Tomohiko Hasegawa:** Investigation, Writing - review & editing. **Go Yoshida:** Investigation, Writing - review & editing. **Mitsuru Hanada:** Investigation, Writing - review & editing. **Tomohiro Banno:** Investigation, Writing - review & editing. **Hideyuki Arima:** Investigation, Writing - review & editing. **Shin Oe:** Investigation, Writing - review & editing. **Tomohiro Yamada:** Investigation, Writing - review & editing. **Yuh Watanabe:** Investigation, Writing - review & editing. **Kenta Kurosu:** Investigation, Writing - review & editing. **Hironobu Hoshino:** Investigation, Project administration, and Writing - review & editing. **Haruo Niwa:** Investigation, Project administration, Writing - review & editing. **Daisuke Togawa:** Investigation, Project administration, and Writing - review & editing. **Yukihiro Matsuyama:** Project administration, Writing - review & editing.

Conflicts of interest

The authors declare no competing interests.

Data availability statement

We are committed to promoting transparency and reproducibility in our research. The data supporting the findings of this study will be made available upon reasonable request. Researchers interested in accessing the data can contact Koichiro Ide at 1de.5one60@gmail.com to discuss the terms of data sharing, including any necessary agreements to ensure ethical and responsible use of the data.

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