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Jyväkorpi, Satu

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High proportions of older people with normal nutritional status have poor protein intake and low diet quality

S.K. Jyväkorpi^{a,*}, K.H. Pitkälä^a, T.M. Puranen^a, M.P. Björkman^a, H. Kautiainen^a,
T.E. Strandberg^b, H.H. Soini^{a,c}, M.H. Suominen^a

^a University of Helsinki, Department of General Practice and Primary Health Care, and Helsinki University Central Hospital, Unit of Primary Health Care, Finland

^b University of Helsinki, Department of Medicine, Geriatric Clinic, Helsinki University Central Hospital, and University of Oulu, Institute of Health Sciences/ Geriatrics, and Oulu University Hospital, Oulu, Finland

^c Helsinki City, Department of Social Services and Health Care, Developmental and Operational Support, Finland

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ABSTRACT

Introduction: The Mini Nutritional Assessment (MNA) is a well-validated instrument examining the nutritional status of older people. The aim of this study was to examine how older people's energy and nutrient intakes are associated with the MNA and to determine how sensitive and specific MNA is in identifying those having low energy and protein intakes.

Materials and methods: This cross-sectional study combined data from five nutritional studies (N = 900): both home-dwelling and institutionalized older people without and with disabilities. Their nutritional status was assessed with MNA, and nutrient intakes were retrieved from 1 to 3 day food diaries. Nutrient intakes were divided according to MNA status (normal nutritional status, at-risk of malnutrition, malnourished). Sensitivity, specificity, and likelihood ratios of MNA of various cut-off points were tested with recommended protein and energy intakes. ROC curves was constructed.

Results: Energy, protein and most nutrient intakes showed logical linear trends according to MNA classes. However, more than three-fourths of the participants with MNA > 23.5 had lower than recommended protein intakes. Sensitivity of MNA ranged from 0.32 to 0.82 for recommended energy (F:1570 kcal/d/ M:2070 kcal/d) and protein intakes (1.0 g/kg BW or 1.2 g/kg BW) cut-off points, and specificity from 0.75 to 0.25, respectively. AUC values were low (0.52–0.53).

Conclusions: MNA status was consistently associated with nutrient intakes and diet quality. However, a high proportion of older people even with normal nutritional status had poor energy and protein intakes. Thus, MNA does not identify all those with poor nutrient intakes who may be at risk of developing malnutrition.

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1. Introduction

A large proportion of older people are at risk of developing malnutrition (Vellas et al., 1999). Malnutrition is most often observed in frail institutionalized older populations (Volkert, 2013), and home care clients (Johnson & Begum, 2004). In addition, home-dwelling older people with comorbidities including Alzheimer's disease are a risk group for malnutrition (Shatenstein, Kergoat, & Reid, 2007). However, even among healthy home-dwelling older people, poor nutrient intakes and low diet quality

have been observed (de Groot, van den Broek, & van Staveren, 1999; Hsiao et al., 2013). Diseases and poor diet quality combined with insufficient nutrient intake may eventually lead to malnutrition (Anderson et al., 2012; Morley et al., 2010). Preventing malnutrition at its' early stages is crucial, because malnutrition leads to loss of muscle mass, functional ability and deterioration of cognition, impairs immunity, and increases falls and mortality (Agarwal et al., 2013; Bauer et al., 2013; Donini et al., 2003).

The Mini Nutritional Assessment (MNA) is a well-validated instrument used to assess the nutritional status of older people (Guigoz, 2006). The MNA divides people into three classes according to nutritional status (normal nutritional status, at risk of malnutrition, and malnourished) (Vellas et al., 1999). The instrument is internationally recognized and widely used to identify malnutrition in older people. Though MNA was designed

* Corresponding author at: Tukholmankatu 8 B, PL 20, 00014 University of Helsinki, Helsinki, Finland.

E-mail address: satu.jyvakorpi@gery.fi (S.K. Jyväkorpi).

to recognize malnutrition of older people, less is known how MNA is associated with daily energy and nutrient intakes. The aim of this study was to assess how energy and nutrient intakes are associated with the MNA, and how sensitive and specific MNA is in identifying those with low energy and protein intakes.

2. Methods

Our study with cross-sectional design combined data from five nutritional studies of older people ($n=900$). The studies included were: 1) Nutrition Education and Cooking Classes study (NC) participants ($n=54$) (Jyväkorpi et al., 2014), 2) older men from the Helsinki Businessmen study (HBS) ($n=68$) (Strandberg et al., 2013), 3) home-dwelling people with Alzheimer's disease (AD) ($n=99$) and 4) their spousal care givers (CG) from the Nutrition in Alzheimers disease- trial (NuAD) ($n=97$) (Jyväkorpi, Puranen, Pitkälä, & Suominen, 2012), 5) participants from the Porvoo Nutrition and Sarcopenia Trial (PNST) ($n=208$) (Björkman, Suominen, Pitkälä, Finne-Soveri, & Tilvis, 2013), and 6) residents of assisted living facilities (ALF) from the Helsinki metropolitan area ($n=374$) (Vikstedt et al., 2011). We excluded people under 60 years of age from our study. The NC participants had the lowest mean age and were mostly healthy home-dwelling older people who were interested in cooking, nutrition and health issues. The HBS group comprised home-dwelling men who had been either businessmen or management executives during their working lives. We used the latest data (2012) from the study in our analysis. The home-dwelling AD and their spousal CG participated in a randomized controlled trial, in which the intervention group received tailored nutritional counseling. We used the baseline findings of the study. The PNST is a study investigating the effects of protein supplementation and home-based exercises on physical performance among home-dwelling older people at risk of sarcopenia. We used the findings of the people screened for the PNST in the present study. ALF residents are institutionalized older people who live in assisted living facilities that are similar to service houses, but more home like.

Cognitive status was measured using the Clinical Dementia Rating Scale (CDR) and with Mini Mental State Examination (MMSE) (Folstein, Folstein, & Mchugh, 1975; Hughes et al., 1982).

Charlson comorbidity index was calculated from reported diagnoses (NC, CG, AD, HBS) or from diagnoses confirmed from medical records (PSNT, ALF) (Charlson, Pompei, Ales, & MacKenzie, 1987).

The use of calcium and vitamin D supplements and the amount of supplements was recorded. In addition, demographic information on the study participants was collected.

Nutritional status was assessed using the MNA (Vellas et al., 1999). Nutrition intakes were retrieved from 1 to 3 day food diaries, which the participants completed themselves (NC, HBS, CG, PNST) or had a caregiver or trained nurse to fill in the diaries for them (AD, ALF). The food diaries were checked and verified by a nutritionist in face-to-face interviews (NC) or by phone calls (CG, AD, PNST, HBS). Dietary intakes were analyzed, using the Nutrica 3.11 or Aivo program (Aivo program, 2014; Rastas et al., 1997).

Intakes of energy, protein, fats, carbohydrates (total, sugar, and fiber), and key micronutrients were divided according to the MNA class (normal nutritional status, risk of malnutrition, malnourished). For calcium and vitamin D, the total intake was taken into account, including supplemental use.

The dietary intakes of protein, other nutrients and fiber among the functional groups were compared with the recommended intake (RI) from the newly released age- and sex-specific dietary reference intakes (Nordic Nutrition Recommendations, 2012) and energy intake from recommendation of National Nutrition Council (National Nutrition Council, 2005). We used the average

requirement (AR) as reference values for inadequate intake of micronutrients (Nordic Nutrition Recommendations, 2012). The AR value is about 2/3 of RIs. Since ARs were not available energy, protein, fiber, or polyunsaturated fatty acids (PUFAs), they were compared with RIs.

Diet quality was defined as adherence to nutrition recommendations (Nordic Nutrition Recommendations, 2012).

2.1. Statistical analysis

Differences between the baseline characteristics were analyzed using the Kruskal-Wallis test, analysis of variance (ANOVA), or Chi-square test. The statistical significance for hypotheses of linearity was evaluated by ANOVA or the Cochran-Armitage Test. Receiver operating

characteristic (ROC) curve was constructed to determine the cut-off point of MNA that corresponds to the protein (1.0 and 1.2 g/kg BW) (Bauer et al., 2013; Nordic Nutrition Recommendations, 2012) and energy intakes (1570 kcal for females, and 2070 kcal for males) (National Nutrition Council, 2005), with bias corrected bootstrap CIs. Values for the area under the ROC curve from 0.7 to 0.8 indicate reasonable discrimination and values exceeding 0.8 indicate good discrimination. We defined the best cut-off value as the value with the highest accuracy that maximizes the Youden's index. Sensitivity, specificity, positive and negative likelihood ratios, Youden's index, and their 95% CI values were calculated. The statistical analysis was performed using SPSS statistical program, version 22 (SPSS, Armonk, NY, USA) and STATA (release 13.1, College Station, TX, USA).

2.2. Ethical standards

This study complies with current laws of the country in which the study was performed.

3. Results

The MNA groups differed significantly in all the background characteristics. The malnourished

people according to MNA were the oldest, more likely to be institutionalized, had the lowest body mass index (BMI), were mostly females, had the most comorbidities, and suffered from poorer cognitive status than people in the normal nutritional status group. Furthermore, the mean BMI between people in the normal nutritional status and at risk of malnutrition-group did not differ. (Table 1)

There was a logical and consistent trend in most micronutrient intakes in the MNA groups. The micronutrient intakes were lowest in the malnourished group in all other micronutrients, except for total calcium and total vitamin D. The largest proportion of subjects using calcium and vitamin D supplements were in the malnourished group. There were no differences in protein intake (g/kg BW) between the groups. There was a clear and statistically significant trend for energy and nutrient intakes to increase from the malnourished group towards the normal nutritional status group. In the contrast, the carbohydrate ($p=0.014$), sugar ($p<0.001$) and total calcium ($p=0.037$) intakes tended to decrease towards the normal nutritional status group, showing the highest intakes in the malnourished group and the lowest in the normal nutritional status-group (Table 2).

Insufficient intake of micronutrients was determined using AR values. The highest proportion of all participants receiving insufficient amounts of micronutrients was observed for vitamins A, D, E, and folate. The intakes of energy, protein, PUFA, and fiber were compared with the RIs. Protein intakes were lower than as recommended (<1.2 g/kg BW) by 77% of the malnourished, 79% in

Table 1
Population characteristics according to MNA-class.

Population characteristics	Malnourished	At risk of malnutrition	Normal nutritional status	p-value ^a
Age (SD)	85.0 (6.8)	82.4 (6.8)	78.5 (7.4)	< 0.001
Female (%)	75	73	55	< 0.001
Charlson	2.5 (1.6)	2.3 (1.5)	1.7 (1.6)	< 0.001
Place of residence (%)				
1 = home	10	43	86	< 0.001
2 = assisted living facilities	90	57	14	
CDR, %				
0 or 0.5 no definite dementia	10	17	69	< 0.001
1 = mild dementia	15	17	15	
2 = moderate dementia	23	38	15	
3 = severe dementia	52	28	1	
MMSE	24.3 (3.6)	24.3 (4.9)	26.1 (4.4)	< 0.001
BMI	21.5 (4.6)	26.5 (4.7)	26.4 (3.8)	< 0.001
Use of Vitamin D supplements,%	63	48	53	0.05

BMI = Body mass index. Charlson = comorbidity index (Charlson et al., 1987). CDR = degree of dementia (Hughes et al., 1982). MMSE = Mini mental state examination (Folstein et al., 1975). BMI = Body mass index. Charlson = comorbidity index (Charlson et al., 1987). CDR = degree of dementia (Hughes et al., 1982). MMSE = Mini mental state examination (Folstein et al., 1975).

^a Differences between the groups for categorical variables were tested with X²-test or Fischer exact test and for non-normally distributed continuous variables with Kruskal-Wallis test.

Table 2
Energy and nutrient intake according to MNA-class.

Energy and nutrient intakes	Malnutrition ^a n = 72	At risk of malnutrition ^a n = 449	Normal nutritional status ^a n = 379	p-value ^a
Energy total kcal, mean (SD)	1592 (421)	1661 (454)	1715 (446)	0.016
Among females	1553 (358)	1598 (427)	1665 (412)	0.031
Among males	1708 (569)	1829 (482)	1776 (479)	0.80
Protein total g, mean (SD)	55.8 (18.0)	65.6 (21.4)	73.3 (22.2)	< 0.001
g/kg BW/d, mean (SD)	1.0 (0.3)	1.0 (0.4)	1.0 (0.4)	0.15
Carbohydrates total g, mean (SD)	209.0 (66.3)	205.0 (63.9)	195.1 (59.6)	0.014
Sugar	68.9 (36.1)	52.7 (31.1)	39.2 (24.1)	< 0.001
Fiber	13.2 (5.1)	16.8 (6.9)	20.9 (8.0)	< 0.001
Fat total g, mean (SD)	56.4 (19.2)	60.4 (22.1)	66.6 (24.6)	< 0.001
SFA	23.7 (9.0)	24.6 (10.0)	26.2 (9.7)	0.008
MUFA	16.2 (7.2)	16.3 (8.3)	20.2 (11.5)	< 0.001
PUFA	7.3 (5.3)	11.2 (7.5)	13.5 (7.9)	< 0.001
Vitamin C mg, mean (SD)	91 (52)	95 (58)	103 (65)	0.044
Folate μg, mean (SD)	195 (68)	232 (104)	264 (120)	< 0.001
Thiamine mg, mean (SD)	1.1 (0.4)	1.2 (0.4)	1.2 (0.4)	0.031
Vitamin E mg, mean (SD)	5.9 (2.6)	7.2 (3.3)	9.7 (4.6)	< 0.001
Vitamin A μg, mean (SD)	583 (518)	841 (1212)	1111 (1462)	< 0.001
Total vitamin D μg, mean (SD)	18.4 (9.8)	17.2 (11.4)	18.9 (12.8)	0.19
Dietary, mean (SD)	6.5 (4.6)	8.5 (6.6)	10 (7.6)	< 0.001
Supplemental, mean (SD)	11.9 (9)	8.7 (9.3)	8.9 (11)	0.16
Total calcium mg, mean (SD)	1391 (616)	1344 (590)	1253 (528)	0.010
Dietary, mean (SD)	1013 (413)	1057 (435)	989 (376)	0.093
Supplemental, mean (SD)	377 (422)	287 (405)	264 (386)	0.05
Iron mg, mean (SD)	8.1 (4.0)	9.2 (3.3)	10.3 (3.6)	< 0.001
Zinc mg, mean (SD)	8.7 (2.9)	10.0 (3.3)	10.9 (3.1)	< 0.001

SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

^a Measured with Mini Nutritional Assessment (MNA) (Vellas et al., 1999).

^{*} Statistical significance for hypotheses of linearity was evaluated by analysis of variance (ANOVA).

the at-risk of malnutrition group, and 74% of the normal nutritional status group, respectively. The proportions of participants receiving less than the RI of protein did not differ between the MNA groups ($p=0.20$). The fiber intakes were low in all of the MNA groups. The PUFA intake was lowest in the malnourished group, in which 82% received less than the RI, and highest in the normal

nutritional status group, in which the corresponding percentage was 32% (Fig. 1).

The sensitivity and specificity for protein intake of 1.0 g/kg BW/d was 0.57 and 0.52, respectively and for protein intake of 1.2 g/kg BW/d 0.82 and 0.25, respectively. The sensitivity and specificity for energy intake according to RI were 0.32 and 0.75, respectively. AUC

Fig. 1. Panel 1. Proportion of older people in nutritional status groups (malnutrition, risk of malnutrition, normal nutritional status), measured by Mini nutritional assessment (MNA), reaching the recommended intakes (RI) for energy, protein, fiber and polyunsaturated fatty acids (PUFA) (Nordic Nutrition Recommendations, 2012). Panel 2. Proportion of older people in nutritional status groups (malnutrition, risk of malnutrition, normal nutritional status), measured by Mini nutritional assessment (MNA), reaching the average requirements (AR) for vitamins A, D, E, C and folate (Nordic Nutrition Recommendations, 2012).

values of MNA were low for both recommended protein and energy intakes even using the best cut-off values with the highest accuracy. Table 3 presents the sensitivity and specificity rates, AUC values and positive and negative likelihood ratios of MNA compared to recommended protein and energy intakes.

4. Discussion

In our study, MNA status was consistently associated with diet quality and nutrient intakes. The poorest nutrient intakes were

observed among the malnourished and the highest intakes in those with normal nutritional status. However, even in people with normal nutritional status, a large proportion had low energy and protein intakes and insufficient micronutrient intakes. Apparently, the MNA has low sensitivity and specificity to identify those with poor energy and protein intakes and who, thus, may be at risk for developing malnutrition.

The strength of this study was its large sample size and diverse older populations resulting from combining of data from various nutritional studies. Combining data gave our study more statistical

Table 3

Sensitivity and specificity rates, positive and negative likelihood ratios (LR) of MNA compared to protein intake cut points 1.0 g/kg BW, 1.2 g/kg BW and energy intake cut points of 1570 kcal for females and 2070 kcal for males. Area under the curve (AUC) values were calculated for respective receiver operating (ROC) curves.

Measurements	AUC (95% CI)	MNA cut-off ^a point	Sensitivity (95% CI)	Specificity (95% CI)	LR ⁺ ^b (95% CI)	LR ⁻ ^b (95% CI)
Protein 1.0 g/kg BW ^c	0.53 (0.49–0.57)	<23	0.57 (0.52–0.61)	0.52 (0.47–0.57)	1.17 (1.03–1.33)	0.84 (0.73–0.96)
1.2 g/kg BW ^d	0.53 (0.49–0.58)	<26	0.82 (0.78–0.84)	0.25 (0.20–0.32)	1.09 (1.00–1.19)	0.73 (0.55–0.96)
Energy ^e F: 1570 kcal M: 2070 kcal	0.52 (0.48–0.55)	<21	0.32 (0.27–0.36)	0.75 (0.71–0.79)	1.28 (1.03–1.58)	0.91 (0.84–0.97)

^a Best cut-off value for Mini Nutritional Assessment (MNA) as the value with the highest accuracy that maximizes the Youden's index (Vellas et al., 1999).

^b LR⁺, LR⁻ positive and negative likelihood ratios (LR).

^c According to PROT-AGE study group (Bauer et al., 2013).

^d According to Nordic Nutrition Recommendations (Nordic Nutrition Recommendations, 2012).

^e According to the recommendation of National Nutritional council (National Nutrition Council, 2005).

power, allowing each MNA group to have a high number of people. A limitation of this study was its cross-sectional design, furthermore, combining different datasets is always challenging although similar methods were used in all of the studies. Assessing food intake with precision is difficult. People may under- or overestimate their dietary intakes or change their food consumption patterns. However, in the datasets of the five nutritional studies used in our investigation, all the possible steps, including face-to-face interviews with a nutritionist and phone calls to verify the food records were taken to obtain as accurate information of participants' food intake as possible. Furthermore, the fact that in our study, the people with better nutritional status, also had better energy and nutrient intakes, supports the fact that the dietary records were accurate. In two of the studies, the participants filled 3-day food diaries, while in the other three studies only 1-day food diaries were utilized. Use of just 1-day food diaries may be problematic, because a person's average food intake can vary over a longer period of time. However, in group level with high number of participants, even one-day diet records can be used to estimate dietary intake and this is a common practice in many epidemiological studies (Basiotis et al., 1987). Furthermore, food diaries have been a valid and suitable instrument in examining nutrient intakes of older people (Gariballa & Forster, 2008).

Age, female sex, poor cognition, comorbidities, institutionalization, and BMI were associated with malnutrition. These observations confirm findings from previous studies (Guigoz, 2006; Shatenstein et al., 2007; Volkert, 2013). However, protein (g/kg BW) intakes were surprisingly not associated with malnutrition. Although the energy intakes of the malnourished or at risk of malnutrition participants were not much lower than in people with normal nutritional status, their micronutrient intakes were lower in these first mentioned two groups, which suggests low nutrient density of the consumed foods.

It has been suggested that home-dwelling older people may suffer more often from insufficient protein and micronutrient, rather than poor energy intakes (Johnson & Begum, 2004). The carbohydrate and sugar use were the highest in the malnutrition group whereas they were lowest in the normal nutrition status group. Since the fiber intake showed an opposite trend and was the lowest in the malnutrition group and increased towards the normal nutritional status, it is reasonable to assume the malnutrition groups consumed high amounts of low quality carbohydrates. High consumption of low-quality carbohydrates may cause protein and micronutrient dilution (Charlton, Kolbe-Alexander, & Ne, 2005).

Optimal protein intake for older people has been widely debated over the recent years in the scientific community. There is a widely accepted consensus among the scientists though, that the physiological need for protein rises as a person ages (Bauer et al., 2013; Morley et al., 2010). In our study protein intakes were less than recommended according to Nordic Nutrition Recommendation in 74% of people with normal nutritional status. In these recently published recommendations, a protein intake for people over 65 years of age of 1.2–1.4 g/kg BW/d was endorsed (Nordic Nutrition Recommendations, 2012). In a review by Bauer et al. (2013) a somewhat lower protein intake for older people of 1.0–1.2 g/kg BW/d was recommended. Less than half of the people with normal nutritional status, or who were at risk of malnutrition, attained this recommendation. The European Food Safety Authority has suggested even lower protein recommendation for older people of 0.83 g/kg BW/d, which equals to the amount recommended for the younger population. Even this low recommendation was not obtained by about one third of the people with normal nutritional status. Sufficient protein intake in older people is crucial for the prevention of sarcopenia, maintenance of muscle mass, and functional ability (Bauer et al., 2013; Morley et al., 2010).

Clearly there is a need to increase protein intake, not only in the frail older populations with comorbidities, but also in the functional and healthy older population.

Since the AR is approximately 2/3 the level of RI, the micronutrient intakes of the participants in our study were much lower than the optimal intakes (RIs). Furthermore, physiological conditions, such as inflammation, may increase protein and micronutrient needs (Bauer et al., 2013). Insufficient intakes were most often observed in vitamins D, E and folate, as they were in the normal nutritional status group. About one-fifth of the entire sample had insufficient vitamin C intakes. Calcium intake was adequate in all MNA-groups. Recorded calcium intake was highest in the malnutrition group and decreased towards the normal nutrition status. This was partly due to the fact, that we also recorded the supplemental calcium use. The use of calcium supplements and the amount of used supplemental calcium were highest in the malnutrition group. Calcium supplemental use was very similar in the malnutrition risk group and with normal nutritional status group.

The findings of this study may be generalized to older population because the study participants represent the heterogeneity of older population varying from healthy older adults to institutionalized older people.

The MNA-status was logically associated with energy and nutrient intakes. However, the sensitivity and specificity of MNA in identifying people with sub-optimal protein and energy intakes were low. Logically, MNA was not designed for identifying people with low diet quality and poor nutrient intakes. The MNA is though often the only instrument used in clinical practice. It is thus important to use other dietary assessment tools such as food records, food frequency questionnaires or other appropriate tools in addition to MNA in order to recognize older people with low diet quality and poor nutrient intakes that may be at risk of malnutrition and frailty. There is a clear need to increase protein intake and improve diet quality not only in the malnourished older people, but also in the healthy and still functional older populations.

5. Conclusions

The MNA scores were positively associated with nutrient intakes. However, the MNA failed to recognize people with low energy and protein intakes. Though, also people with normal nutritional status may have inadequate nutrient intakes and may thus be at risk of malnutrition. Interventions to improve the diet quality and nutrient intakes of older people are needed.

Conflicts of interest

The authors have no conflict of interest in regard to this article in question.

More specifically here are the specific statements of each author:

SKJ: reports having received lecturing fees from pharmaceutical company Actavis.

KHP: Dr Pitkälä reports having received lecturing fees from pharmaceutical companies (including Lundbeck, Orion), and having participated in clinical trials funded by pharmaceutical companies.

TMP: reports no conflict of interest.

MPB: Dr Bjorkman has received lecture fees from Valio Ltd. and Valio Ltd. also provided the nutritional supplements used in the Porvoo sarcopenia & nutrition trial that was started after the baseline assessments reported in this study.

HK: reports no conflict of interest.

TES: reports of having various educational and consultative cooperation with several companies including Nutricia, Abbott, Amgen, Merck, Pfizer, Novartis, NovoNordisk, minor amount of stock in OrionPharma, President of the European Union Geriatric Medicine Society, which has cooperation also with nutrition industry.

HS: reports no conflict of interest.

MHS: reports having received lecture fees from Nutricia and Verman Ltd.

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