Description

Title of Invention: NOVEL OXYNTOMODULIN DERIVATIVES AND PHARMACEUTICAL COMPOSITION FOR TREATING OBESITY COMPRISING THE SAME

Technical Field

[1] The present invention relates to a novel peptide showing excellent activities on a glucagon like peptide-1 receptor and a glucagon receptor greater than native oxyntomodulin, and a composition for the prevention or treatment of obesity comprising the peptide as an active ingredient.

[2]

Background Art

[3] Recently, economic growth and changes in lifestyle are leading to changes in eating habits. The main causes of rising overweight and obesity rates in contemporary people are consumption of high-calorie foods such as fast foods and lack of exercise. World Health Organization (WHO) estimates that more than 1 billion people worldwide are overweight and at least 300 million of them are clinically obese. In particular, 250,000 people die each year in Europe and more than 2.5 million people worldwide die each year as a result of being overweight (World Health Organization, Global Strategy on Diet, Physical Activity and Health, 2004).

[4] Being overweight and obese increases blood pressure and cholesterol levels to cause occurrence or exacerbation of various diseases such as cardiovascular disease, diabetes, and arthritis, and are also main causes of rising incidence rates of arteriosclerosis, hypertension, hyperlipidemia or cardiovascular disease in children or adolescents as well as in adults.

[5] Obesity is a severe condition that causes various diseases worldwide. It is thought to be overcome by individual efforts, and it is also believed that obese patients lack self-control. However, it is difficult to treat obesity, because obesity is a complex disorder involving appetite regulation and energy metabolism. For the treatment of obesity, abnormal actions associated with appetite regulation and energy metabolism should be treated together with efforts of obese patients. Many attempts have been made to develop drugs capable of treating the abnormal actions. As the result of these efforts, drugs such as Rimonabant (Sanofi-Aventis), Sibutramin (Abbott), Contrave (Takeda), and Orlistat (Roche) have been developed, but they have the disadvantages of serious adverse effects or very weak anti-obesity effects. For example, it was reported that Rimonabant (Sanofi-Aventis) shows a side-effect of central nerve disorder, Sibutramine (Abbott) and Contrave (Takeda) show cardiovascular side-effects, and Orlistat (Roche)

shows only 4 kg of weight loss when taken for 1 year. Unfortunately, there are no therapeutic agents for obesity which can be safely prescribed for obese patients.

[6]

[7] Many studies have been made to develop therapeutic agents for obesity which do not have the problems of the conventional anti-obesity drugs. Recently, glucagon derivatives have received much attention. Glucagon is produced by the pancreas when the level of glucose in the blood drops resulting from other medications or diseases, hormone or enzyme deficiencies. Glucagon stimulates glycogen breakdown in the liver, and facilitates glucose release to raise blood glucose levels to a normal range. In addition to the effect of increasing the blood glucose level, glucagon suppresses appetite and activates hormone-sensitive lipase(HSL) of adipocytes to facilitate lipolysis, thereby showing anti-obesity effects. One of the glucagon derivatives, glucagon like peptide-1 (GLP-1) is under development as a therapeutic agent for hyperglycemia in patients with diabetes, and it functions to stimulate insulin synthesis and secretion, to inhibit glucagon secretion, to slow gastric emptying, to increase glucose utilization, and to inhibit food intake. Exendin-4 is isolated from lizard venom that shares approximately 50% amino acid homology with GLP-1 and is also reported to activate the GLP-1 receptor, thereby ameliorating hyperglycemia in patients with diabetes. However, anti-obesity drugs including GLP-1 are reported to show side-effects such as vomiting and nausea.

[8] As an alternative to GLP-1, therefore, much attention has been focused on oxyntomodulin, a peptide derived from a glucagon precursor, pre-glucagon that binds to the receptors of two peptides, GLP-1 and glucagon. Oxyntomodulin represents a potent anti-obesity therapy, because it inhibits food intake like GLP-1, promotes satiety, and has a lipolytic activity like glucagon.

[9] Based on the dual function of the oxyntomodulin peptide, it has been actively studied as a drug for the treatment of obesity. For example, Korean Patent No. 925017 discloses a pharmaceutical composition including oxyntomodulin as an active ingredient for the treatment of overweight human, which is administered via an oral, parenteral, mucosal, rectal, subcutaneous, or transdermal route. However, it has been reported that this anti-obesity drug including oxyntomodulin has a short in vivo half-life and weak therapeutic efficacy, even though administered at a high dose three times a day. Thus, many efforts have been made to improve the in vivo half-life or therapeutic effect of oxyntomodulin on obesity by its modification.

[10] For example, a dual agonist oxyntomodulin (Merck) is prepared by substituting L-serine with D-serine at position 2 of oxyntomodulin to increase a resistance to dipeptidyl peptidase-IV (DPP-IV) and by attaching a cholesterol moiety at the C-terminal to increase the blood half-life at the same time. ZP2929 (Zealand) is prepared

by substituting L-serine with D-serine at position 2 to enhance resistance to DPP-IV, substituting arginine with alanine at position 17 to enhance resistance to protease, substituting methionine with lysine at position 27 to enhance oxidative stability, and substituting glutamine with aspartic acid and alanine at positions 20 and 24 and asparagine with serine at position 28 to enhance deamidation stability. However, even though the half-life of the dual agonist oxyntomodulin (Merck) was enhanced to show half-life 8~12 minutes longer than the native oxyntomodulin, it still has a very short in vivo half-life of 1.7 hr and its administration dose is also as high as several mg/kg. Unfortunately, oxyntomodulin or derivatives thereof have disadvantages of daily administration of high dose due to the short half-life and low efficacy.

[11]

Disclosure of Invention

Technical Problem

[12] Accordingly, the present inventors have developed an oxyntomodulin derivative prepared by modifying the amino acid sequence of native oxyntomodulin in order to enhance its therapeutic effects on obesity and to reduce its administration dose. As a result, they found that the oxyntomodulin derivative shows more excellent activities on a glucagon receptor and a GLP-1 receptor than native oxyntomodulin, thereby completing the present invention.

[13]

Solution to Problem

[14] An object of the present invention is to provide a novel peptide showing excellent therapeutic effects on obesity.

[15] Another object of the present invention is to provide a composition for the prevention or treatment of obesity, comprising the peptide.

[16] Still another object of the present invention is to provide a method for preventing or treating obesity by administering the peptide or the composition to a subject.

[17] Still another object of the present invention is to provide use of the peptide in the preparation of drugs for the prevention or treatment of obesity.

[18]

Advantageous Effects of Invention

[19] Unlike native oxyntomodulin, the novel peptide of the present invention reduces food intake, suppresses gastric emptying, and facilitates lipolysis without side-effects, and also shows excellent receptor-activating effects. Thus, it can be widely used in the treatment of obesity with safety and efficacy.

[20]

Brief Description of Drawings

[21] FIG. 1 is a graph showing changes in food intake according to administration dose of oxyntomodulin or oxyntomodulin derivative.

[22]

Best Mode for Carrying out the Invention

[23] In one aspect to achieve the above objects, the present invention provides a novel peptide including the amino acid sequence of the following Formula 1.

[24]

[25] R1-X1-X2-GTFTSD-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19-X20-X21-X22-X23-X24-R2 (Formula 1)

[26] wherein R1 is histidine, desamino-histidyl, dimethyl-histidyl (N-dimethyl-histidyl), beta-hydroxyimidazopropionyl, 4-imidazoacetyl, beta-carboxy imidazopropionyl or tyrosine;

[27] X1 is Aib(aminoisobutyric acid), d-alanine, glycine, Sar(N-methylglycine), serine, or d-serine;

[28] X2 is glutamic acid or glutamine;

[29] X3 is leucine or tyrosine;

[30] X4 is serine or alanine;

[31] X5 is lysine or arginine;

[32] X6 is glutamine or tyrosine;

[33] X7 is leucine or methionine;

[34] X8 is aspartic acid or glutamic acid;

[35] X9 is glutamic acid, serine, alpha-methyl-glutamic acid or is deleted;

[36] X10 is glutamine, glutamic acid, lysine, arginine, serine or is deleted;

[37] X11 is alanine, arginine, valine or is deleted;

[38] X12 is alanine, arginine, serine, valine or is deleted;

[39] X13 is lysine, glutamine, arginine, alpha-methyl-glutamic acid or is deleted;

[40] X14 is aspartic acid, glutamic acid, leucine or is deleted;

[41] X15 is phenylalanine or is deleted;

[42] X16 is isoleucine, valine or is deleted;

[43] X17 is alanine, cysteine, glutamic acid, lysine, glutamine, alpha-methyl-glutamic acid or is deleted;

[44] X18 is tryptophan or is deleted;

[45] X19 is alanine, isoleucine, leucine, serine, valine or is deleted;

[46] X20 is alanine, lysine, methionine, glutamine, arginine or is deleted;

[47] X21 is asparagine or is deleted;

[48] X22 is alanine, glycine, threonine or is deleted;

[49] X23 is cysteine, lysine or is deleted;

[50] X24 is a peptide having 2 to 10 amino acids consisting of combinations of alanine, glycine and serine, or is deleted; and

[51] R2 is KRNRNNIA (SEQ ID NO. 32), GPSSGAPPPS (SEQ ID NO. 33), GPSSGAPPPSK (SEQ ID NO. 34), HSQGTFTSDYSKYLD (SEQ ID NO. 35), HSQGTFTSDYSRYLDK (SEQ ID NO. 36), HGEGTFTSDLSKQMEEEAVK (SEQ ID NO. 37) or is deleted (excluded if the amino acid sequence of Formula 1 is identical to that of SEQ ID NO. 1).

[52]

[53] As used herein, the term "peptide" means a compound of two or more α-amino acids linked by a peptide bond. With respect to the objects of the present invention, it means a peptide that activates both the GLP-1 receptor and the glucagon receptor to show anti-obesity effects. The peptide according to the present invention includes peptides, peptide derivatives or peptide mimetics that are prepared by addition, deletion or substitution of amino acids of oxyntomodulin so as to activate both of the GLP-1 receptor and the glucagon receptor at a high level, compared to the native oxyntomodulin.

[54] Amino acids mentioned herein are abbreviated according to the nomenclature rule of IUPAC-IUB as follows:

[55]

[56] Alanine A Arginine R

[57] Asparagine N Aspartic acid D

[58] Cysteine C Glutamic acid E

[59] Glutamine Q Glycine G

[60] Histidine H Isoleucine I

[61] Leucine L Lysine K

[62] Methionine M Phenylalanine F

[63] Proline P Serine S

[64] Threonine T Tryptophan W

[65] Tyrosine Y Valine V

[66]

[67] In the present invention, the peptide encompasses any peptide that is prepared by substitutions, additions, deletions or post translational modifications (e.g., methylation, acylation, ubiquitination, intramolecular covalent bonding) in the amino acid sequence of oxyntomodulin (HSQGTFTSDYSKYLDSRRAQDFVQWLMNTKRNRNNIA, SEQ ID NO. 1) so as to activate the glucagon and GLP-1 receptors at the same time. Upon substitution or addition of amino acids, any of the 20 amino acids commonly found in human proteins, as well as atypical or non-naturally occurring amino acids can be used. Commercially available sources of atypical amino acids include Sigma-Aldrich, ChemPep Inc., and Genzyme Pharmaceuticals. The peptides including these

amino acids and atypical peptide sequences may be synthesized and purchased from commercial suppliers, for example, American Peptide Company or Bachem (USA) or Anygen (Korea).

[68] In order to enhance the activity of the wild-type oxyntomodulin for the glucagon receptor and the GLP-1 receptor, the peptide of the present invention may be substituted with 4-imidazoacetyl where the alpha carbon of histidine at position 1 of amino acid sequence represented by SEQ ID NO. 1 is deleted, desamino-histidyl where the N-terminal amino group is deleted, dimethyl-histidyl (N-dimethyl-histidyl) where the N-terminal amino group is modified with two methyl groups, beta-hydroxy imidazopropionyl where the N-terminal amino group is substituted with a hydroxyl group, or beta-carboxy imidazopropionyl where the N-terminal amino group is substituted with a carboxyl group. In addition, the GLP-1 receptor-binding region may be substituted with amino acids that enhance hydrophobic and ionic bonds or combinations thereof. A part of the oxyntomodulin sequence may be substituted with the amino acid sequence of GLP-1 or Exendin-4 to enhance the activity on GLP-1 receptor.

[69] Further, a part of the oxyntomodulin sequence may be substituted with a sequence stabilizing alpha helix. Preferably, amino acids at positions 10, 14, 16, 20, 24 and 28 of the amino acid sequence of Formula 1 may be substituted with amino acids or amino acid derivatives consisting of Tyr(4-Me), Phe, Phe(4-Me), Phe(4-Cl), Phe(4-CN), Phe(4-NO_2), Phe(4-NH_2), Phg, Pal, Nal, Ala(2-thienyl) and Ala(benzothienyl) that are known to stabilize alpha helix, and there are no limitations on the type and number of alpha helix-stabilizing amino acid or amino acid derivatives to be inserted. Preferably, amino acids at positions 10 and 14, 12 and 16, 16 and 20, 20 and 24, and 24 and 28 may be also substituted with glutamic acid or lysine, respectively so as to form rings, and there is no limitation on the number of rings to be inserted. Most preferably, the peptide may be a peptide having an amino acid sequence selected from the following Formulae 2 to 6.

[70]

[71] In one specific embodiment, the peptide of the present invention is an oxyntomodulin derivative including the amino acid sequence of the following Formula 2 where the amino acid sequence of oxyntomodulin is substituted with that of exendin or GLP-1.

[72]

[73] R1-A-R3 (Formula 2)

[74]

[75] In another specific embodiment, the peptide of the present invention is an oxyntomodulin derivative including the amino acid sequence of the following Formula 3, which is prepared by linking a part of the amino acid sequence of oxyntomodulin and a part of the amino acid sequence of exendin or GLP-1 via a proper amino acid linker.

[76]

[77] R1-B-C-R4 (Formula 3)

[78]

[79] In still another specific embodiment, the peptide of the present invention is an oxyntomodulin derivative including the amino acid sequence of the following Formula 4, wherein a part of the amino acid sequence of oxyntomodulin is substituted with an amino acid capable of enhancing the binding affinity to GLP-1 receptor, for example, Leu at position 26 which binds with GLP-1 receptor by hydrophobic interaction is substituted with the hydrophobic residue, Ile or Val.

[80]

[81] R1-SQGTFTSDYSKYLD-D1-D2-D3-D4-D5-LFVQW-D6-D7-N-D8-R3 (Formula 4)

[82]

[83] In still another specific embodiment, the peptide of the present invention is an oxyntomodulin derivative including the following Formula 5, wherein a part of the amino acid sequence is deleted, added, or substituted with other amino acid in order to enhance the activities of native oxyntomodulin on GLP-1 receptor and glucagon receptor.

[84]

[85] R1-E1-QGTFTSDYSKYLD-E2-E3-RA-E4-E5-FV-E6-WLMNT-E7-R5 (Formula 5)

[86]

[87] In Formulae 2 to 5, R1 is the same as in the description of Formula 1;

[88] A is selected from the group consisting of SQGTFTSDYSKYLDSRRAQDFVQWLMNT (SEQ ID NO. 38), SQGTFTSDYSKYLDEEAVRLFIEWLMNT (SEQ ID NO. 39), SQGTFTSDYSKYLDERRAQDFVAWLKNT (SEQ ID NO. 40), GQGTFTSDYSRYLEEEAVRLFIEWLKNG (SEQ ID NO. 41), GQGTFTSDYSRQMEEEAVRLFIEWLKNG (SEQ ID NO. 42), GEGTFTSDLSRQMEEEAVRLFIEWAA (SEQ ID NO. 43), and SQGTFTSDYSRQMEEEAVRLFIEWLMNG (SEQ ID NO. 44);

[89] B is selected from the group consisting of SQGTFTSDYSKYLDSRRAQDFVQWLMNT (SEQ ID NO. 38), SQGTFTSDYSKYLDEEAVRLFIEWLMNT (SEQ ID NO. 39), SQGTFTSDYSKYLDERRAQDFVAWLKNT (SEQ ID NO. 40), GQGTFTSDYSRYLEEEAVRLFIEWLKNG (SEQ ID NO. 41), GQGTFTSDYSRQMEEEAVRLFIEWLKNG (SEQ ID NO. 42), GEGTFTSDLSRQMEEEAVRLFIEWAA (SEQ ID NO. 43), SQGTFTSDYSRQMEEEAVRLFIEWLMNG (SEQ ID NO. 44), GEGTFTSDLSRQMEEEAVRLFIEW (SEQ ID NO. 45), and SQGTFTSDYSRYLD (SEQ ID NO. 46);

[90] C is a peptide having 2 to 10 amino acids consisting of combinations of alanine,

glycine and serine;

[91] D1 is serine, glutamic acid or arginine;

[92] D2 is arginine, glutamic acid or serine;

[93] D3 is arginine, alanine or valine;

[94] D4 is arginine, valine or serine;

[95] D5 is glutamine, arginine or lysine;

[96] D6 is isoleucine, valine or serine;

[97] D7 is methionine, arginine or glutamine;

[98] D8 is threonine, glycine or alanine;

[99] E1 is serine, Aib, Sar, d-alanine or d-serine;

[100] E2 is serine or glutamic acid;

[101] E3 is arginine or lysine;

[102] E4 is glutamine or lysine;

[103] E5 is aspartic acid or glutamic acid;

[104] E6 is glutamine, cysteine or lysine;

[105] E7 is cysteine, lysine or is deleted;

[106] R3 is KRNRNNIA (SEQ ID NO. 32), GPSSGAPPPS (SEQ ID NO. 33) or GPSSGAPPPSK (SEQ ID NO. 34);

[107] R4 is HSQGTFTSDYSKYLD (SEQ ID NO. 35), HSQGTFTSDYSRYLDK (SEQ ID NO. 36) or HGEGTFTSDLSKQMEEEAVK (SEQ ID NO. 37); and,

[108] R5 is KRNRNNIA (SEQ ID NO. 32), GPSSGAPPPS (SEQ ID NO. 33), GPSSGAPPPSK (SEQ ID NO. 34) or is deleted (excluded if the amino acid sequences of Formula 2 to 5 are identical to that of SEQ ID NO. 1).

[109]

[110] Preferably, the novel peptide of the present invention may be a peptide of the following Formula 6.

[111]

[112] R1-X1-X2-GTFTSD-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19-X20-X21-X22-X23-X24-R2 (Formula 6)

[113]

[114] wherein R1 is histidine, desamino-histidyl, 4-imidazoacetyl or tyrosine;

[115] X1 is Aib(aminoisobutyric acid), glycine or serine;

[116] X2 is glutamic acid or glutamine;

[117] X3 is leucine or tyrosine;

[118] X4 is serine or alanine;

[119] X5 is lysine or arginine;

[120] X6 is glutamine or tyrosine;

[121] X7 is leucine or methionine;

[122] X8 is aspartic acid or glutamic acid;

[123] X9 is glutamic acid, alpha-methyl-glutamic acid or is deleted;

[124] X10 is glutamine, glutamic acid, lysine, arginine or is deleted;

[125] X11 is alanine, arginine or is deleted;

[126] X12 is alanine, valine or is deleted;

[127] X13 is lysine, glutamine, arginine, alpha-methyl-glutamic acid or is deleted;

[128] X14 is aspartic acid, glutamic acid, leucine or is deleted;

[129] X15 is phenylalanine or is deleted;

[130] X16 is isoleucine, valine or is deleted;

[131] X17 is alanine, cysteine, glutamic acid, glutamine, alpha-methyl-glutamic acid or is deleted;

[132] X18 is tryptophan or is deleted;

[133] X19 is alanine, isoleucine, leucine, valine or is deleted;

[134] X20 is alanine, lysine, methionine, arginine or is deleted;

[135] X21 is asparagine or is deleted;

[136] X22 is threonine or is deleted;

[137] X23 is cysteine, lysine or is deleted;

[138] X24 is a peptide having 2 to 10 amino acids consisting of glycine or is deleted; and

[139] R2 is KRNRNNIA (SEQ ID NO. 32), GPSSGAPPPS (SEQ ID NO. 33), GPSSGAPPPSK (SEQ ID NO. 34), HSQGTFTSDYSKYLD (SEQ ID NO. 35), HSQGTFTSDYSRYLDK (SEQ ID NO. 36), HGEGTFTSDLSKQMEEEAVK (SEQ ID NO. 37) or is deleted (excluded if the amino acid sequence of Formula 6 is identical to that of SEQ ID NO. 1).

[140]

[141] More preferably, the peptide of the present invention may be selected from the group consisting of the peptides of SEQ ID NOs. 1 to 31. Much more preferably, the peptide of the present invention may be an oxyntomodulin derivative described in Table 1 of Example 2-1.

[142] Oxyntomodulin has activities of two peptides, GLP-1 and glucagon. GLP-1 decreases blood glucose, reduces food intake, and suppresses gastric emptying, and glucagon increases blood glucose, facilitate lipolysis and decreases body-weight by increasing energy metabolisms. Different biological effects of two peptides can cause undesired effects like increasing blood glucose if glucagon shows more dominant effect than GLP-1, or causing nausea and vomiting if GLP-1 shows more dominant effect than glucagon. Therefore, the oxyntomodulin derivatives of the present invention are not only aimed to increase these activities, for example, amino acids at position 1 and 11 of oxyntomodulin which suppress the activity of glucagon, may be modified for balancing the activity ratios of glucagon and GLP-1.

[143] The present inventors performed in vitro experiments to demonstrate that the peptide of the present invention shows excellent activities on the GLP-1 receptor and the glucagon receptor, compared to oxyntomodulin. Thus, it is suggested that the peptide of the present invention activates the GLP-1 receptor and the glucagon receptor to show more excellent therapeutic effects on obesity than the conventional oxyntomodulin. In addition, its inhibitory effects on in vivo food intake were examined, and it shows more excellent inhibitory effects on food intake than the conventional oxyntomodulin (FIG. 1).

[144]

[145] It is apparent to those skilled in the art that when the oxyntomodulin derivatives of the present invention are modified using the typical techniques, including modification with polymers such as PEG and sugar chain or fusion with albumin, transferrin, fatty acid, and immunoglobulin in order to improve the therapeutic effects of the oxyntomodulin derivatives, they will show superior therapeutic effects to native oxyntomodulin. Therefore, the modified oxyntomodulin derivatives are also included in the scope of the present invention.

[146]

[147] In another aspect, the present invention provides a polynucleotide encoding the peptide.

[148] The term "homology", as used herein for the polynucleotide, indicates sequence similarity between wild-type amino acid sequences or wild-type nucleotide sequences, and includes a gene sequence that is 75% or higher, preferably 85% or higher, more preferably 90% or higher and even more preferably 95% or higher identical to the polynucleotide sequence encoding the peptide. The homology evaluation may be done with the naked eye or using a commercially available program. Using a commercially available computer program, the homology between two or more sequences may be expressed as a percentage (%), and the homology (%) between adjacent sequences may be evaluated. The polynucleotide encoding the peptide is inserted into a vector and expressed so as to obtain a large amount of the peptide.

[149]

[150] In still another aspect, the present invention provides a pharmaceutical composition for the prevention or treatment of obesity comprising the peptide.

[151] As used herein, the term "prevention" means all of the actions by which the occurrence of obesity is restrained or retarded by administration of the peptide or the composition, and the term "treatment" means all of the actions by which the symptoms of obesity have taken a turn for the better or been modified favorably by administration of the peptide or the composition.

[152] As used herein, the term "administration" means introduction of an amount of a pre-

determined substance into a patient by a certain suitable method. The composition of the present invention may be administered via any of the common routes, as long as it is able to reach a desired tissue, for example, but is not limited to, intraperitoneal, intravenous, intramuscular, subcutaneous, intradermal, oral, topical, intranasal, intrapulmonary, or intrarectal administration. However, since peptides are digested upon oral administration, active ingredients of a composition for oral administration should be coated or formulated for protection against degradation in the stomach.

[153] As used herein, the term "obesity" implies accumulation of an excess amount of adipose tissue in the body, and a body mass index (body weight (kg) divided by the square of the height (m)) above 25 is to be regarded as obesity. Obesity is usually caused by an energy imbalance, when the amount of dietary intake exceeds the amount of energy expended for a long period of time. Obesity is a metabolic disease that affects the whole body, and increases the risk for diabetes, hyperlipidemia, sexual dysfunction, arthritis, and cardiovascular diseases, and in some cases, is associated with incidence of cancer.

[154] The pharmaceutical composition of the present invention may further include a pharmaceutically acceptable carrier, excipient, or diluent. As used herein, the term "pharmaceutically acceptable" means that the composition is sufficient to achieve the therapeutic effects without deleterious side effects, and may be readily determined depending on the type of the diseases, the patient's age, body weight, health conditions, gender, and drug sensitivity, administration route, administration mode, administration frequency, duration of treatment, drugs used in combination or coincident with the composition of this invention, and other factors known in medicine.

[155] The pharmaceutical composition including the derivative of the present invention may further include a pharmaceutically acceptable carrier. For oral administration, the carrier may include, but is not limited to, a binder, a lubricant, a disintegrant, an excipient, a solubilizer, a dispersing agent, a stabilizer, a suspending agent, a colorant, and a flavorant. For injectable preparations, the carrier may include a buffering agent, a preserving agent, an analgesic, a solubilizer, an isotonic agent, and a stabilizer. For preparations for topical administration, the carrier may include a base, an excipient, a lubricant, and a preserving agent.

[156] The composition of the present invention may be formulated into a variety of dosage forms in combination with the aforementioned pharmaceutically acceptable carriers. For example, for oral administration, the pharmaceutical composition may be formulated into tablets, troches, capsules, elixirs, suspensions, syrups or wafers. For injectable preparations, the pharmaceutical composition may be formulated into an ampule as a single dosage form or a multidose container. The pharmaceutical composition may also be formulated into solutions, suspensions, tablets, pills, capsules and

long-acting preparations.

[157] On the other hand, examples of the carrier, the excipient, and the diluent suitable for the pharmaceutical formulations include lactose, dextrose, sucrose, sorbitol, mannitol, xylitol, erythritol, maltitol, starch, acacia rubber, alginate, gelatin, calcium phosphate, calcium silicate, cellulose, methylcellulose, microcrystalline cellulose, polyvinylpyrrolidone, water, methylhydroxybenzoate, propylhydroxybenzoate, talc, magnesium stearate and mineral oils. In addition, the pharmaceutical formulations may further include fillers, anti-coagulating agents, lubricants, humectants, flavorants, and antiseptics.

[158] Further, the pharmaceutical composition of the present invention may have any formulation selected from the group consisting of tablets, pills, powders, granules, capsules, suspensions, liquids for internal use, emulsions, syrups, sterile aqueous solutions, non-aqueous solvents, lyophilized formulations and suppositories.

[159] Further, the composition may be formulated into a single dosage form suitable for the patient's body, and preferably is formulated into a preparation useful for peptide drugs according to the typical method in the pharmaceutical field so as to be administered by an oral or parenteral route such as through skin, intravenous, intramuscular, intraarterial, intramedullary, intramedullary, intraventricular, pulmonary, transdermal, subcutaneous, intraperitoneal, intranasal, intracolonic, topical, sublingual, vaginal, or rectal administration, but is not limited thereto.

[160] The peptide may be used by blending with a variety of pharmaceutically acceptable carriers such as physiological saline or organic solvents. In order to increase the stability or absorptivity, carbohydrates such as glucose, sucrose or dextrans, antioxidants such as ascorbic acid or glutathione, chelating agents, low molecular weight proteins or other stabilizers may be used.

[161]

[162] The administration dose and frequency of the pharmaceutical composition of the present invention are determined by the type of active ingredient, together with various factors such as the disease to be treated, administration route, patient's age, gender, and body weight, and disease severity.

[163] The total effective dose of the composition of the present invention may be administered to a patient in a single dose, or may be administered for a long period of time in multiple doses according to a fractionated treatment protocol. In the pharmaceutical composition of the present invention, the content of active ingredient may vary depending on the disease severity. Preferably, the total daily dose of the peptide of the present invention may be approximately 0.0001 μg to 500 mg per 1 kg of body weight of a patient. However, the effective dose of the peptide is determined considering various factors including patient's age, body weight, health conditions, gender, disease

severity, diet, and secretion rate, in addition to administration route and treatment frequency of the pharmaceutical composition. In view of this, those skilled in the art may easily determine an effective dose suitable for the particular use of the pharmaceutical composition of the present invention. The pharmaceutical composition according to the present invention is not particularly limited to the formulation, and administration route and mode, as long as it shows the effects of the present invention.

[164] The pharmaceutical composition of the present invention shows excellent in-vivo duration of efficacy and titer, thereby remarkably reducing the number and frequency of administration thereof.

[165] Moreover, the pharmaceutical composition may be administered alone or in combination or coincident with other pharmaceutical formulations showing prophylactic or therapeutic effects on obesity. The pharmaceutical formulations showing prophylactic or therapeutic effects on obesity are not particularly limited, and may include a GLP-1 receptor agonist, a leptin receptor agonist, a DPP-IV inhibitor, a Y5 receptor antagonist, a Melanin-concentrating hormone (MCH) receptor antagonist, a Y2/3 receptor agonist, a MC3/4 receptor agonist, a gastric/pancreatic lipase inhibitor, a 5HT2c agonist, a β3A receptor agonist, an Amylin receptor agonist, a Ghrelin antagonist, and/or a Ghrelin receptor antagonist.

[166]

[167] In still another aspect, the present invention provides a method for preventing or treating obesity, comprising the step of administering to a subject the peptide or the pharmaceutical composition including the same.

[168] In the present invention, the term "subject" is those suspected of having obesity, which means mammals including human, mouse, and livestock having obesity or having the possibility of obesity. However, any subject to be treated with the peptide or the pharmaceutical composition of the present invention is included without limitation. The pharmaceutical composition including the peptide of the present invention is administered to a subject suspected of having obesity, thereby treating the subject effectively. The obesity is as described above.

[169] The therapeutic method of the present invention may include the step of administering the composition including the peptide at a pharmaceutically effective amount. The total daily dose should be determined through appropriate medical judgment by a physician, and administered once or several times. With respect to the objects of the present invention, the specific therapeutically effective dose level for any particular patient may vary depending on various factors well known in the medical art, including the kind and degree of the response to be achieved, concrete compositions according to whether other agents are used therewith or not, the patient's age, body weight, health condition, gender, and diet, the time and route of administration, the secretion rate of

the composition, the time period of therapy, other drugs used in combination or co-incident with the composition of this invention, and like factors well known in the medical arts.

[170]

[171] In still another aspect, the present invention provides a use of the peptide or the pharmaceutical composition including the same in the preparation of drugs for the prevention or treatment of obesity.

[172]

Mode for the Invention

[173] Hereinafter, the present invention will be described in more detail with reference to the following Examples. However, these Examples are for illustrative purposes only, and the invention is not intended to be limited by these Examples.

[174]

[175] **Example 1. Production of in vitro activated cell line**

[176]

[177] **Example 1-1: Production of cell line showing cAMP response to GLP-1**

[178] PCR was performed using a region corresponding to ORF (Open Reading Frame) in cDNA (OriGene Technologies, Inc. USA) of human GLP-1 receptor gene as a template, and the following forward and reverse primers including each of the HindIII and EcoRI restriction sites so as to obtain a PCR product.

[179]

[180] Forward primer: 5'-CCCGGCCCCCGCGGCCGCTATTCGAAATAC-3'(SEQ ID NO. 47)

[181] Reverse primer: 5'-GAACGGTCCGGAGGACGTCGACTCTTAAGATAG-3'(SEQ ID NO. 48)

[182]

[183] The PCR product was cloned into the known animal cell expression vector x0GC/dhfr to prepare a recombinant vector x0GC/GLP1R.

[184] CHO DG44 cell line cultured in DMEM/F12 (10% FBS) medium was transfected with the recombinant vector x0GC/GLP1R using Lipofectamine (Invitrogen, USA), and cultured in a selection medium containing 1 mg/mL G418 and 10 nM methotraxate. Single clone cell lines were selected therefrom by a limit dilution technique, and a cell line showing excellent cAMP response to GLP-1 in a concentration-dependent manner was finally selected therefrom.

[185]

[186] **Example 1-2: Production of cell line showing cAMP response to glucagon**

[187] PCR was performed using a region corresponding to ORF in cDNA (OriGene Tech-

nologies, Inc. USA) of human glucagon receptor gene as a template, and the following forward and reverse primers including each of the EcoRI and XhoI restriction sites so as to obtain a PCR product.

[188]

[189] Forward primer: 5'-CAGCGACACCGACCGTCCCCCCGTACTTAAGGCC-3'(SEQ ID NO. 49)

[190] Reverse primer: 5'-CTAACCGACTCTCGGGGAAGACTGAGCTCGCC-3'(SEQ ID NO. 50)

[191]

[192] The PCR product was cloned into the known animal cell expression vector x0GC/dhfr to prepare a recombinant vector x0GC/GCGR.

[193] CHO DG44 cell line cultured in DMEM/F12 (10% FBS) medium was transfected with the recombinant vector x0GC/GCGR using Lipofectamine, and cultured in a selection medium containing 1 mg/mL G418 and 10 nM methotraxate. Single clone cell lines were selected therefrom by a limit dilution technique, and a cell line showing excellent cAMP response to glucagon in a concentration-dependent manner was finally selected therefrom.

[194]

[195] **Example 2. Test on in vitro activity of oxyntomodulin derivatives**

[196]

[197] **Example 2-1: Synthesis of oxyntomodulin derivatives**

[198] In order to measure in vitro activities of oxyntomodulin derivatives, oxyntomodulin derivatives having the following amino acid sequences were synthesized (Table 1).

[199]

[200] Table 1

[Table 1]

Oxyntomodulin and oxyntomodulin derivatives

SEQIDNO.	**Aminoacidsequence**
SEQ ID NO. 1	HSQGTFTSDYSKYLDSRRAQDFVQWLMNTKRNRNNIA
SEQ ID NO. 2	CA-SQGTFTSDYSKYLDEEAVRLFIEWLMNTKRNRNNIA
SEQ ID NO. 3	CA-SQGTFTSDYSKYLDERRAQDFVAWLKNTGPSSGAPPPS
SEQ ID NO. 4	CA-GQGTFTSDYSRYLEEEAVRLFIEWLKNGGPSSGAPPPS
SEQ ID NO. 5	CA-GQGTFTSDYSRQMEEEAVRLFIEWLKNGGPSSGAPPPS
SEQ ID NO. 6	CA-GEGTFTSDLSRQMEEEAVRLFIEWAAHSQGTFTSDYSKYLD
SEQ ID NO. 7	CA-SQGTFTSDYSRYLDEEAVRLFIEWLMNTK
SEQ ID NO. 8	CA-SQGTFTSDLSRQLEEEAVRLFIEWLMNK
SEQ ID NO. 9	CA-GQGTFTSDYSRYLDEEAVXLFIEWLMNTKRNRNNIA
SEQ ID NO. 10	CA-SQGTFTSDYSRQMEEEAVRLFIEWLMNGGPSSGAPPPSK
SEQ ID NO. 11	CA-GEGTFTSDLSRQMEEEAVRLFIEWAAHSQGTFTSDYSRYLDK
SEQ ID NO. 12	CA-SQGTFTSDYSRYLDGGGHGEGTFTSDLSKQMEEEAVK
SEQ ID NO. 13	CA-SQGTFTSDYSRYLDXEAVXLFIEWLMNTK
SEQ ID NO. 14	CA-GQGTFTSDYSRYLDEEAVXLFIXWLMNTKRNRNNIA
SEQ ID NO. 15	CA-GQGTFTSDYSRYLDEEAVRLFIXWLMNTKRNRNNIA
SEQ ID NO. 16	CA-SQGTFTSDLSRQLEGGGHSQGTFTSDLSRQLEK
SEQ ID NO. 17	CA-SQGTFTSDYSRYLDEEAVRLFIEWIRNTKRNRNNIA
SEQ ID NO. 18	CA-SQGTFTSDYSRYLDEEAVRLFIEWIRNGGPSSGAPPPSK
SEQ ID NO. 19	CA-SQGTFTSDYSRYLD **E** EAV **K** LFIEWIRN-TKRNRNNIA
SEQ ID NO. 20	CA-SQGTFTSDYSRYLD **E** EAV **K** LFIEWIRNGG-PSSGAPPPSK

SEQ ID NO. 21	CA-SQGTFTSDYSRQLEEEAVRLFIEWVRNTKRNRNNIA
SEQ ID NO. 22	DA-SQGTFTSDYSKYLD **E** KRA **K** EFVQWLMNTK
SEQ ID NO. 23	HAibQGTFTSDYSKYLDEKRAKEFVCWLMNT
SEQ ID NO. 24	HAibQGTFTSDYSKYLDEKRAKEFVQWLMNTC
SEQ ID NO. 25	HAibQGTFTSDYSKYLD **E** KRA **K** EFVQWLMNTC
SEQ ID NO. 26	HAibQGTFTSDYS **K** YLD **E** KRAKEFVQWLMNTC
SEQ ID NO. 27	HAibQGTFTSDYSKYLD **E** QAA **K** EFICWLMNT
SEQ ID NO. 28	HAibQGTFTSDYSKYLDEKRAKEFVQWLMNT
SEQ ID NO. 29	CA-AibQGTFTSDYSKYLD **E** KRA **K** EFVQWLMNTC
SEQ ID NO. 30	HAibQGTFTSDYAKYLD **E** KRA **K** EFVQWLMNTC
SEQ ID NO. 31	YAibQGTFTSDYSKYLD **E** KRA **K** EFVQWLMNTC

[201]

[202] In Table 1, amino acids in bold and underlined represent ring formation, and amino acids represented by X mean a non-native amino acid, alpha-methyl-glutamic acid. In addition, CA represents 4-imidazoacetyl, and DA represents desamino-histidyl.

[203]

[204] **Example 2-2: Test on in vitro activity of oxyntomodulin derivatives**

[205] In order to measure anti-obesity efficacies of the oxyntomodulin derivatives synthesized in Example 2-1, cell activity was measured in vitro using the cell lines prepared in Examples 1-1 and 1-2.

[206] The cell lines were those prepared by transfecting CHO (Chinese Hamster Ovary) to express human GLP-1 receptor gene and glucagon receptor gene, respectively. Thus, they are suitable to measure GLP-1 and glucagon activities. Therefore, the activity of each oxyntomodulin derivative was measured using each transformed cell line.

[207] Specifically, each cell line was sub-cultured twice or three time a week, and aliquoted in each well of a 96-well plate at a density of 1 X 10^5, followed by cultivation for 24 hours.

[208] The cultured cells were washed with KRB buffer and suspended in 40 ml of KRB buffer containing 1 mM IBMX, and left at room temperature for 5 minutes. Oxyntomodulin (SEQ ID NO. 1) and oxyntomodulin derivatives (represented by SEQ ID NOs. 2-6, 8, 10-13, 17, 18, 23-25, 27-30 and 31) were diluted from 1000 nM to 0.02 nM by 5-fold serial dilution, and each 40 mL thereof was added to the cells, and cultured at 37°C for 1 hour in a CO2 incubator. Then, 20 mL of cell lysis buffer was added for cell lysis, and the cell lysates were applied to a cAMP assay kit (Molecular Device, USA) to measure cAMP concentrations. EC_{50} values were calculated

therefrom, and compared to each other. EC_{50} values are shown in the following Table 2.

[209]

[210] Table 2

[Table 2]

Comparison of in vitro activities for GLP-1 receptor and glucagon receptor between oxyntomodulin and oxyntomodulin derivatives

SEQ ID NO.	EC_{50}(nM)	
	CHO/GLP-1R	CHO/GCGR
SEQ ID NO. 1	50 - 210	10 - 43
SEQ ID NO. 2	51.8	12.8
SEQ ID NO. 3	>1,000	637.7
SEQ ID NO. 4	5.5	>1,000
SEQ ID NO. 5	5.9	>1,000
SEQ ID NO. 6	500.1	>1,000
SEQ ID NO. 8	419.6	>1,000
SEQ ID NO. 10	>1,000	>1,000
SEQ ID NO. 11	>1,000	>1,000
SEQ ID NO. 12	>1,000	>1,000
SEQ ID NO. 13	>1,000	>1,000
SEQ ID NO. 17	97.9	>1,000
SEQ ID NO. 18	96.3	>1,000
SEQ ID NO. 23	2.46	5.8
SEQ ID NO. 24	1.43	6.95
SEQ ID NO. 25	1.9	1.3
SEQ ID NO. 27	2.8-5.5	3.1-5.6
SEQ ID NO. 28	3.1	0.3
SEQ ID NO. 29	14.25	17.3
SEQ ID NO. 30	2.20	80.2
SEQ ID NO. 31	12.5	1.0

[211]

[212] As shown in Table 2, there were oxyntomodulin derivatives showing excellent in

vitro activities and different ratios of activities on GLP-1 receptor and glucagon receptor, compared to native oxyntomodulin of SEQ ID NO. 1.

[213]

[214] It is known that oxyntomodulin activates both the GLP-1 receptor and glucagon receptor to suppress appetite, facilitate lipolysis, and promote satiety, thereby showing anti-obesity effects. The oxyntomodulin derivatives according to the present invention show higher in vitro activities on both the GLP-1 receptor and glucagon receptor than the wild-type oxyntomodulin, and therefore can be used as a therapeutic agent for obesity with higher efficacies than the known oxyntomodulin.

[215]

[216] **Example 3. Test on in vivo activity of oxyntomodulin derivatives**

[217] In order to measure in vivo therapeutic activity of oxyntomodulin derivatives, changes in food intake by administration of oxyntomodulin derivatives were examined in ob/ob mouse using native oxyntomodulin as a control.

[218]

[219] Specifically, obese diabetic ob/ob mice, commonly used to test the efficacies of therapeutic agents for obesity and diabetes, were fasted for 16 hours, and administered with 1 or 10 mg/kg of oxyntomodulin, or 0.02, 0.1, 1 or 10 mg/kg of the oxyntomodulin derivative of SEQ ID NO. 2. Then, food intake was examined for 2 hours (FIG. 1). FIG. 1 is a graph showing changes in food intake according to administration dose of oxyntomodulin or oxyntomodulin derivative. As shown in FIG. 1, administration of 1 mg/kg of oxyntomodulin derivative showed more excellent inhibitory effects on food intake than administration of 10 mg/kg of oxyntomodulin.

[220]

[221] Taken together, the oxyntomodulin derivatives of the present invention have much higher anti-obesity effects than the wild-type oxyntomodulin, even though administered at a lower dose, indicating improvement in the problems of the wild-type oxyntomodulin that shows lower anti-obesity effects and should be administered at a high dose three times a day.

[222]

Claims

[Claim 1] A peptide comprising the amino acid sequence of following Formula 1:
R1-X1-X2-GTFTSD-X3-X4-X5-X6-X7-X8-X9-X10-X11-X12-X13-X14-X15-X16-X17-X18-X19-X20-X21-X22-X23-X24-R2 (Formula 1)
wherein R1 is histidine, desamino-histidyl, dimethyl-histidyl (N-dimethyl-histidyl), beta-hydroxyimidazopropionyl, 4-imidazoacetyl, beta-carboxy imidazopropionyl or tyrosine;
X1 is Aib(aminoisobutyric acid), d-alanine, glycine, Sar(N-methylglycine), serine, or d-serine;
X2 is glutamic acid or glutamine;
X3 is leucine or tyrosine;
X4 is serine or alanine;
X5 is lysine or arginine;
X6 is glutamine or tyrosine;
X7 is leucine or methionine;
X8 is aspartic acid or glutamic acid;
X9 is glutamic acid, serine, alpha-methyl-glutamic acid or is deleted;
X10 is glutamine, glutamic acid, lysine, arginine, serine or is deleted;
X11 is alanine, arginine, valine or is deleted;
X12 is alanine, arginine, serine, valine or is deleted;
X13 is lysine, glutamine, arginine, alpha-methyl-glutamic acid or is deleted;
X14 is aspartic acid, glutamic acid, leucine or is deleted;
X15 is phenylalanine or is deleted;
X16 is isoleucine, valine or is deleted;
X17 is alanine, cysteine, glutamic acid, lysine, glutamine, alpha-methyl-glutamic acid or is deleted;
X18 is tryptophan or is deleted;
X19 is alanine, isoleucine, leucine, serine, valine or is deleted;
X20 is alanine, lysine, methionine, glutamine, arginine or is deleted;
X21 is asparagine or is deleted;
X22 is alanine, glycine, threonine or is deleted;
X23 is cysteine, lysine or is deleted;
X24 is a peptide having 2 to 10 amino acids consisting of combinations of alanine, glycine and serine, or is deleted; and
R2 is KRNRNNIA (SEQ ID NO. 32), GPSSGAPPPS (SEQ ID NO. 33), GPSSGAPPPSK (SEQ ID NO. 34), HSQGTFTSDYSKYLD (SEQ

ID NO. 35), HSQGTFTSDYSRYLDK (SEQ ID NO. 36), HGEGTFTSDLSKQMEEEAVK (SEQ ID NO. 37) or is deleted (excluded if the amino acid sequence of Formula 1 is identical to that of SEQ ID NO. 1).

[Claim 2] The peptide according to claim 1, wherein the peptide is an oxyntomodulin derivative capable of activating GLP-1 receptor and glucagon receptor.

[Claim 3] The peptide according to claim 1, wherein the peptide has anti-obesity effects.

[Claim 4] The peptide according to claim 1, wherein one or more amino acids at positions 10, 14, 16, 20, 24 and 28 of the amino acid sequence of Formula 1 are substituted with amino acids or amino acid derivatives selected from the group consisting of Tyr(4-Me), Phe, Phe(4-Me), Phe(4-Cl), Phe(4-CN), Phe(4-NO2), Phe(4-NH2), Phg, Pal, Nal, Ala(2-thienyl) and Ala(benzothienyl).

[Claim 5] The peptide according to claim 1, wherein one or more amino acid pairs at positions 10 and 14, 12 and 16, 16 and 20, 20 and 24, and 24 and 28 of the amino acid sequence of Formula 1 are substituted with glutamic acid or lysine to form rings.

[Claim 6] The peptide according to claim 1, wherein one or more amino acid pairs at positions 10 and 14, 12 and 16, 16 and 20, 20 and 24, and 24 and 28 of the amino acid sequence of Formula 1 form rings.

[Claim 7] The peptide according to claim 1, wherein the peptide is selected from the group consisting of the peptides of SEQ ID NOs. 1 to 31.

[Claim 8] A polynucleotide encoding the peptide of claim 1.

[Claim 9] A pharmaceutical composition for the prevention or treatment of obesity, comprising the peptide of any one of claims 1 to 7 as an active ingredient.

[Claim 10] The pharmaceutical composition according to claim 9, further comprising a pharmaceutically acceptable carrier.

[Claim 11] The pharmaceutical composition according to claim 9, wherein the composition is administered alone or in combination or coincident with other pharmaceutical formulations showing prophylactic or therapeutic effects on obesity.

[Claim 12] The pharmaceutical composition according to claim 11, wherein the pharmaceutical formulation showing prophylactic or therapeutic effects on obesity is selected from the group consisting of a GLP-1 receptor agonist, a leptin receptor agonist, a DPP-IV inhibitor, a Y5 receptor an-

tagonist, a Melanin-concentrating hormone (MCH) receptor antagonist, a Y2/3 receptor agonist, a MC3/4 receptor agonist, a gastric/pancreatic lipase inhibitor, a 5HT2c agonist, a β3A receptor agonist, an Amylin receptor agonist, a Ghrelin antagonist, and a Ghrelin receptor antagonist.

[Claim 13] A method for preventing or treating obesity, comprising the step of administering to a subject the peptide of any one of claims 1 to 7 or the composition of claim 9.

[Claim 14] Use of the peptide of any one of claims 1 to 7 or the composition of claim 9 in the preparation of drugs for the prevention or treatment of obesity.